



FLEXmax 100

Charge Controller

Owner's Manual





About OutBack Power Technologies

OutBack Power Technologies is a leader in advanced energy conversion technology. OutBack products include true sine wave inverter/chargers, maximum power point tracking charge controllers, and system communication components, as well as circuit breakers, batteries, accessories, and assembled systems.

Grid/Hybrid™

As a leader in off-grid energy systems, which are designed around energy storage, OutBack Power is an innovator in Grid/Hybrid system technology which provides the best of both worlds: grid-tied system savings during normal or daylight operation, and off-grid independence during peak energy times or in the event of a power outage or an emergency. Grid/Hybrid systems have the intelligence, agility, and interoperability to operate in multiple energy modes quickly, efficiently, and seamlessly, in order to deliver clean, continuous and reliable power to residential and commercial users while maintaining grid stability.

Contact Information

Address:	Corporate Headquarters 17825 – 59 th Avenue N.E. Suite B Arlington, WA 98223 USA	European Office Hansastraße 8 D-91126 Schwabach, Germany
Website:	http://www.outbackpower.com	

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IMPORTANT SAFETY INSTRUCTIONS

READ AND SAVE THESE INSTRUCTIONS!

This manual contains important safety instructions for the FLEXmax 100 charge controller.

Symbols Used




	WARNING: Hazard to Human Life This type of notation indicates that the hazard could be harmful to human life.
	CAUTION: Hazard to Equipment This type of notation indicates that the hazard may cause damage to the equipment.
	IMPORTANT: This type of notation indicates that the information provided is important to the installation, operation and/or maintenance of the equipment. Failure to follow the recommendations in such a notation could result in voiding the equipment warranty.
	NOTE: This type of notation indicates that the information provided is important to understanding the operation and limits of the equipment. Failure to follow the recommendations in such a notation could result in improper or failed operation.



MORE INFORMATION

When this symbol appears next to text, it means that more information is available in other manuals relating to the subject. The most common reference is to the *FLEXmax 100 Quick Start Guide*. Another common reference is the system display manual.

General Safety

	WARNING: Limitations on Use This equipment is NOT intended for use with life support equipment or other medical equipment or devices.
	WARNING: Reduced Protection If this product is used in a manner not specified by FLEXmax 100 product literature, the product's internal safety protection may be impaired.
	CAUTION: Equipment Damage Only use components or accessories recommended or sold by OutBack Power Technologies or its authorized agents.



Introduction

Thank you for purchasing a FLEXmax 100 Series Charge Controller. These charge controllers offer an efficient, safe, multi-stage recharging process that prolongs battery life and assures peak performance from a PV array of up to 300 open-circuit volts (V_{oc}).

Audience

This manual provides instructions for installation, setup, and operation of the product. These instructions are for use by qualified personnel who meet all local and governmental code requirements for licensing and training for the installation of electrical power systems with AC and DC voltage up to 600 volts. Failure to install or use this equipment as instructed in the literature can result in damage to the equipment that may not be covered under the limited warranty. This product is only serviceable by qualified personnel.



IMPORTANT:

This manual provides safety guidelines and installation information for the FLEXmax 100 charge controller. It does not provide information about specific brands of PV modules and it supplies limited information on batteries. Contact the supplier of the PV modules or batteries for additional information.

Features

The FLEXmax 100 charge controller uses continuous Maximum Power Point Tracking (MPPT). This function continuously seeks out the maximum power available from a PV array and harvests it. This power is used to recharge the batteries. See page 66 for a description of MPPT.

The FLEXmax 100 has the following features:

- Designed for operation as part of an OutBack Grid/Hybrid™ system
- Supports 24, 36, and 48 Vdc battery voltages
- Wide input voltage range allows the use of a PV array configuration up to 300 V_{oc}
- Controls an equalization cycle manually or automatically
- Rain-proof enclosure
- Logs up to 128 days of operational data
- Field-upgradeable firmware
- Can be remotely monitored and configured (up to 300 feet or 100 meters away) using MATE3s system display
 - ~ MATE3s must use firmware revision 001.002.000 or higher
 - ~ This product is not intended for use with the previous MATE, MATE2, or MATE3 products
- Supports the OPTICS RE™ online tool¹ for a cloud-based remote monitoring and control application
 - ~ Requires the MATE3s or the AXS Port
 - ~ Visit www.outbackpower.com to download the software

Firmware

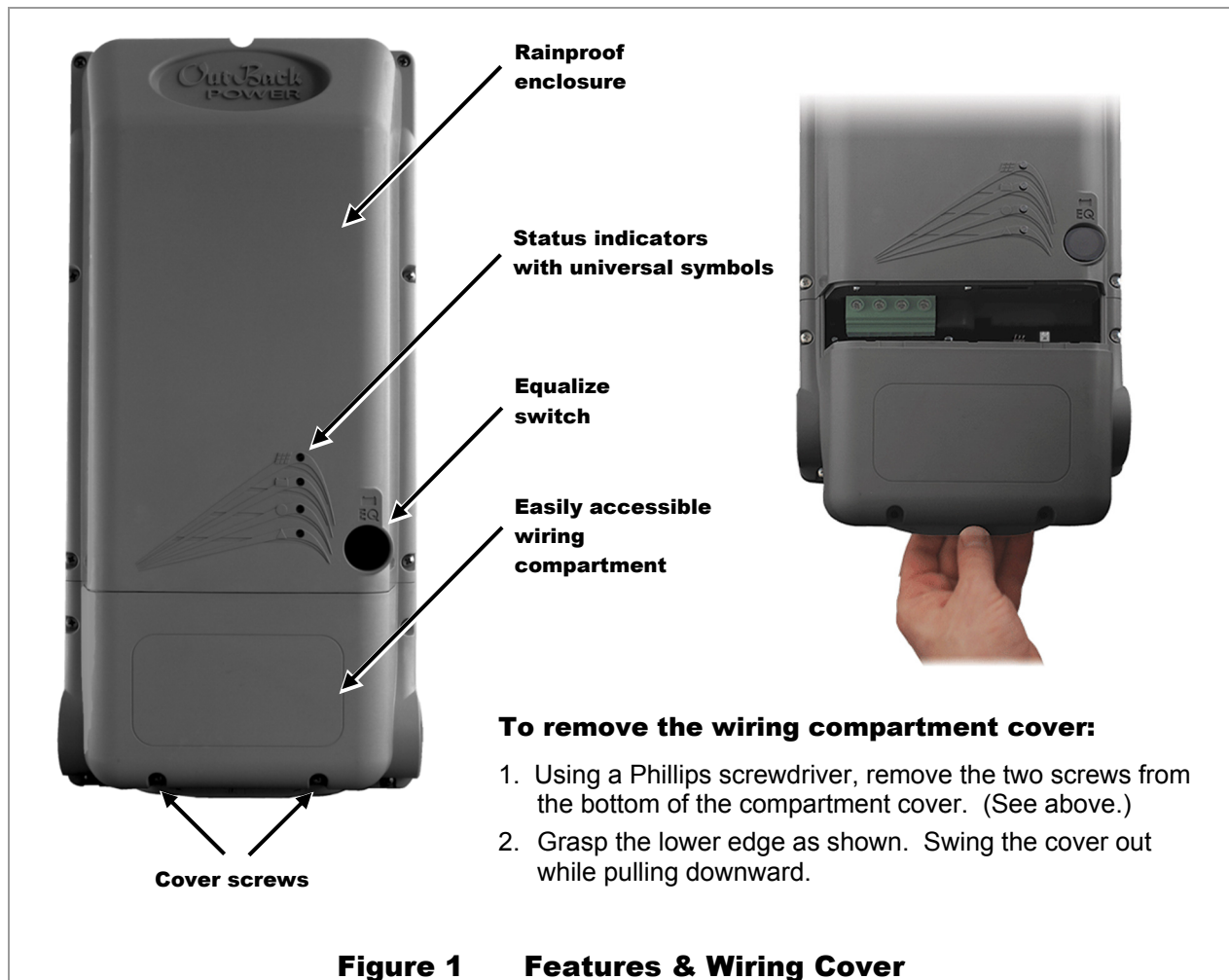
This manual covers FLEXmax 100 firmware revision 001.001.000 or higher.

¹ OutBack Power Technologies Intuitive Control System for Renewable Energy
900-0209-01-00 Rev A

Components and Accessories

Table 1 Components Included

1 × FM 100 Charge Controller
2 × Mounting Bracket
1 × Silicone Grease Package
1 × Fan



Battery Types

The default settings of the FLEXmax 100 charge controller are for lead-chemistry batteries intended for deep discharge. These include all energy storage offered by OutBack Power as well as batteries for marine, golf-cart, and forklift applications. They also include gel-cell batteries and absorbed glass-mat (AGM) batteries. OutBack Power recommends the use of batteries designed specifically for renewable energy applications. Lithium-based batteries and other advanced battery technologies may require special charging considerations.



Installation

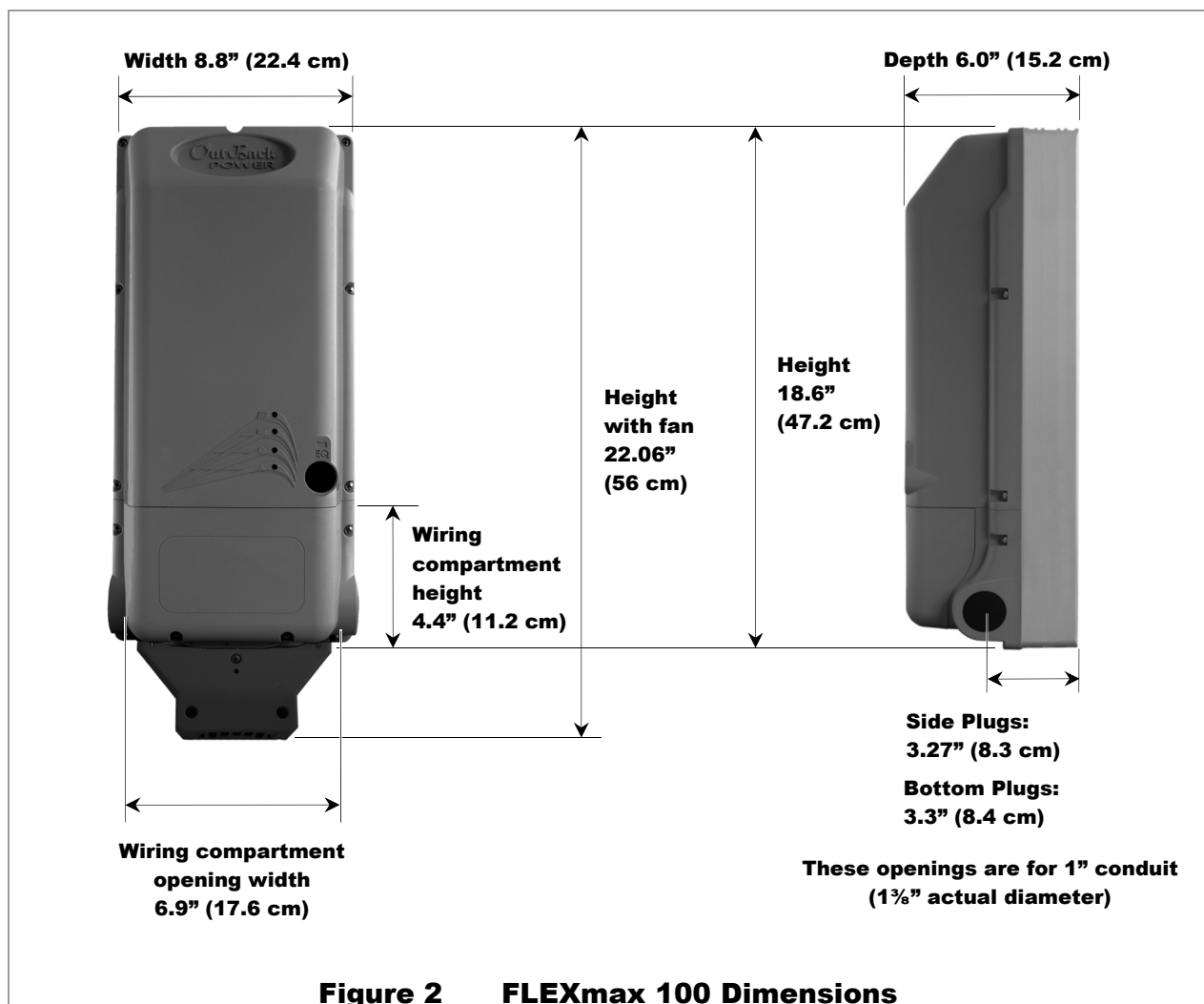
Standards and Requirements

Installations must comply with all national and local electrical codes. Professional installation is recommended. See page 7 for qualifications of installers.

A FLEXmax 100 charge controller operating in unventilated or in other conditions above an ambient temperature of 25°C (77°F) will have a derated power output. See page 61 for more information.

If damaged or malfunctioning, the FLEXmax 100 should only be serviced by qualified personnel. Please contact the local renewable energy dealer/installer for assistance.

Dimensions



Installation

Installing the Fan

The fan must be connected before the controller can be used, though it does not have to be installed first.

To install the cooling fan:

1. Place the fan against the base of the controller. Two of the heat sink fins have holes which receive the locking tabs on the fan. Align the tabs with these fins.
2. Press the fan straight along the fins until the tabs snap into the holes.
3. Insert the fan connector through the hole in the back of the controller and into the fan port in the wiring compartment. (See illustration below; also see page 19.)

Fan installation is complete. The fan will operate automatically based on the internal temperature.

See page 38 to read the temperature using the system display. This page also lists the temperatures at which the fan turns on and off.

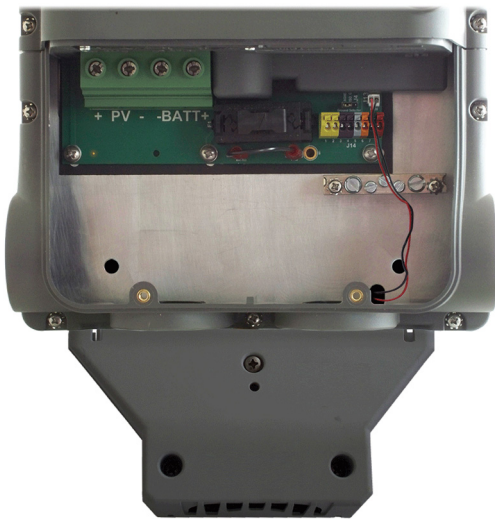
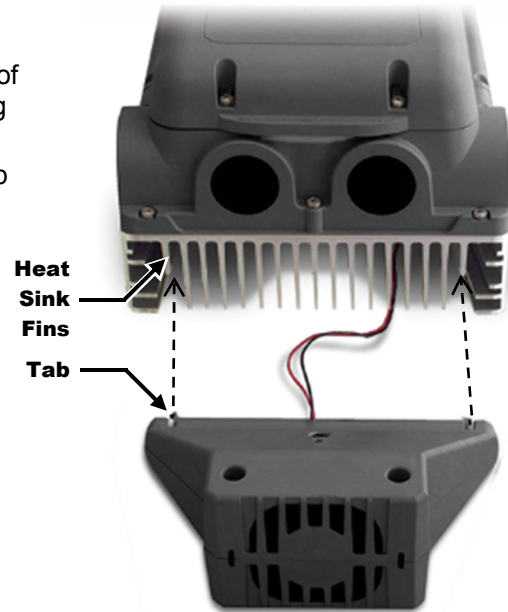


Figure 3 Installing the Fan

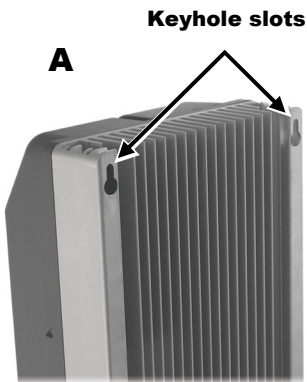
Mounting the Charge Controller

The FLEXmax 100 must be mounted upright on a wall or similar flat upright mounting surface. It must be mounted at least 36" (91.4 cm) above the ground or floor. No other mounting positions are allowed. Installation in shade is recommended.

Clearance requirements include a minimum of 6" (15.2 cm) above and below the controller. On the right and left sides, 1" (2.5 cm) clearance is sufficient. This includes clearance for multiple controllers installed next to each other.

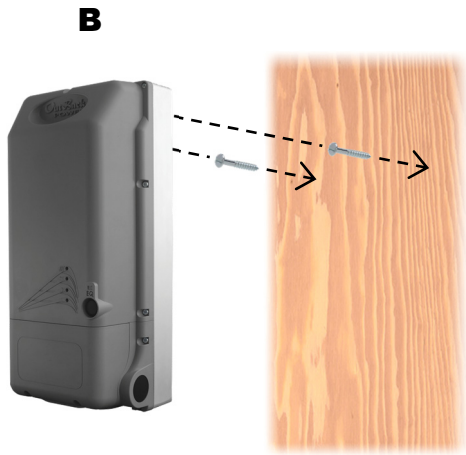
Two mounting methods are available. The first method uses keyhole slots on the back of the controller for hanging directly on a wall. This method is useful for a standalone installation.

Keyhole Slot Mount

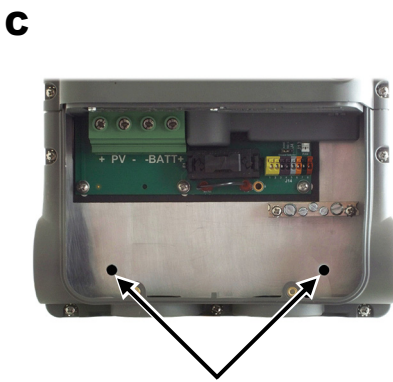


A

Keyhole slots



B



C

Securing holes

To mount using keyhole slots (A):

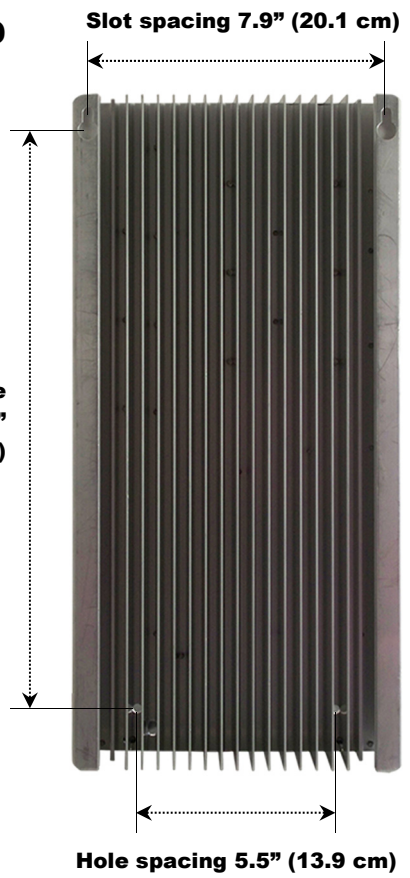
1. Use two slotted #14 wood screws. The mounting surface must be strong enough to support the weight of the FLEXmax 100.

NOTE: OutBack is not responsible for damage resulting from inadequate mounting hardware or preparation.

2. Mark the locations where the screws will be inserted on the surface as in **B**. Space them according to the keyhole slot locations as in **D**.

NOTE: The brackets included with the controller have holes with the same spacing which can be used as a marking template.

3. Using the appropriate tools, set the screws into the surface. The heads should protrude by $\frac{1}{8}$ " (0.3 cm).
4. Hang the FLEXmax 100 by placing its back against the mounting surface and aligning the keyhole slots with the screws. Settle the controller so that the screws seat in the narrow end of each slot.
5. Secure the base of the controller to the surface. Insert two $\frac{1}{4}$ " hex head lag screws into the holes shown in **C**.



D

Slot spacing 7.9" (20.1 cm)

Distance 16.9" (42.9 cm)

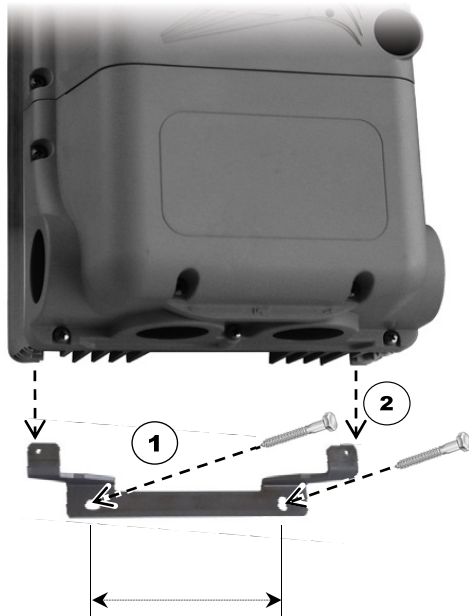
Hole spacing 5.5" (13.9 cm)

Mounting is complete. Proceed to charge controller wiring or other installation steps.

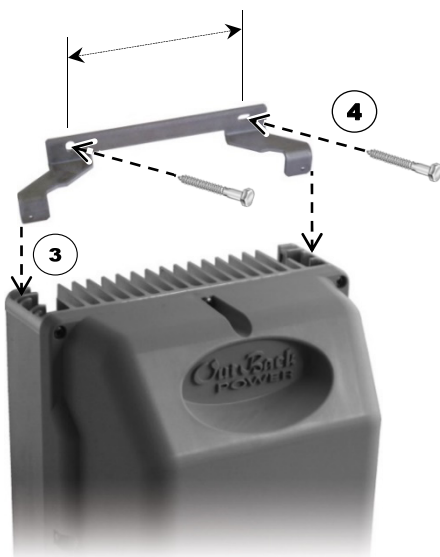
Figure 4 Mounting the Charge Controller (keyhole)

Bracket Mount

The second mounting method uses brackets on the top and bottom of the controller. This method is useful when mounting the controller next to an OutBack inverter system, as the conduit openings will align. It is also useful for mounting without making advance measurements. The FLEXmax 100 controller comes with two identical brackets.



Bracket hole spacing: 5.13" (13.0 mm)



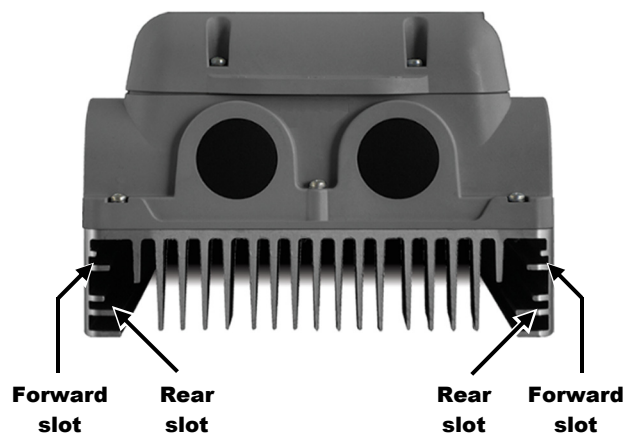
Vertical space between upper and lower bracket holes: About 20" when mounted

To mount using brackets:

1. Using two 1/4" hex head lag screws, mount the lower bracket with the tabs facing upward. The mounting surface must be strong enough to support the added weight of the FLEXmax 100.

NOTE: OutBack is not responsible for damage resulting from inadequate mounting preparation.

2. Lower the FLEXmax 100 onto the bracket as shown to the left. The bracket tabs can be inserted in one of two positions: forward or rear.
 - To mount the controller flush against the wall, insert the tabs in the forward slots as shown below.
 - To mount the controller 0.83" (2.1 cm) from the wall to align with an OutBack mounting plate, insert the tabs in the rear slots as shown below.



NOTE: The charge controller can rest on the lower bracket for the rest of the procedure, although it will need at least one hand to steady it.

3. Insert the upper bracket into the same set of slots as were used with the lower bracket (forward or rear) as shown to the left.
4. Using two 1/4" hex head lag screws, attach the upper bracket to the mounting surface as shown to the left.

Mounting is complete. Proceed to charge controller wiring or other installation steps.


Figure 5 Mounting the Charge Controller (brackets)



Wiring

This section provides instructions on installing PV array wiring into the charge controller. See page 65 for more notes on PV array sizing. All wiring must comply with local and national codes.



Grounding

This product is intended to be installed as part of a permanently grounded electrical system. This grounding is shown in the wiring diagrams in this book. Grounding methods must comply with local and national codes.

The FLEXmax 100 equipment ground is marked with this symbol: 

	<p>IMPORTANT:</p> <ul style="list-style-type: none"> ❖ The FLEXmax 100 includes internal ground-fault protection and meets the requirements of the 2017 National Electric Code, Article 690.41(A)(1) for two-wire PV arrays with one functional grounded conductor. ❖ Bonding one of the battery conductors to ground is required for NEC compliance and is strongly recommended in any case. The product comes with a functional bond established from negative to ground. For positive-ground installation, see page 14. ❖ The battery conductor (positive or negative) must be bonded to the grounding system at only <i>one</i> point. An external bond should not be present elsewhere in the system unless the bond in the FLEXmax 100 is intentionally removed. If present, another bond will defeat the GFDI protection. See page 15. ❖ If required, external ground-fault protection can be used with this product, such as the OutBack GFDI or PV system grounding in compliance with NEC 690A(5). See page 15.
	<p>CAUTION: Equipment Damage</p> <ul style="list-style-type: none"> ❖ For positive-ground systems: <ul style="list-style-type: none"> ~ The FLEXmax 100 internal GFDI function cannot be used in a positive-ground system. It must be disabled before use. Any GFDI protection must be external. ~ This product can be used in a positive-ground system when networked with one OutBack inverter and a HUB communications manager. It cannot be networked in a positive-ground system with multiple inverters. See page 14 for other requirements in a positive-ground system. ~ For use of the FLEXnet DC Battery Monitor or other devices in these applications, see page 70. ❖ Failure to follow these instructions can damage the controller and other devices. This damage is not covered under warranty.

Negative-Ground Systems

	<p>WARNING: Shock Hazard</p> <p>Failure to bond one battery conductor to the grounding system can present a risk of electric shock.</p>
	<p>CAUTION: Equipment Damage</p> <p>Failure to follow ground bonding instructions can damage the FLEXmax 100 and other devices. This damage is not covered under warranty. Failure to follow these instructions may also result in noncompliance with NEC or other codes.</p>

The FLEXmax 100 uses a jumper wire to create a functional ground for one conductor. Connecting this wire completes a mechanical connection (bond) between one battery conductor and the ground. The default position creates a negative-to-ground bond, the most common configuration (item **A** in Figure 6).

Installation

The negative jumper position also completes a connection to the internal ground fault detection and interruption (GFDI) circuit. (See the GFDI section on page 15.)



NOTE:

When installing multiple controllers, remove the bonding jumper from all controllers but the first one. Do not remove all bonds from the system.

Removing the bonding jumper wires from all controllers may result in an unbonded system unless a bond is established elsewhere. Note that disconnecting the wires will also defeat the internal GFDI function. Establishing a bond elsewhere will not allow the GFDI function to work.

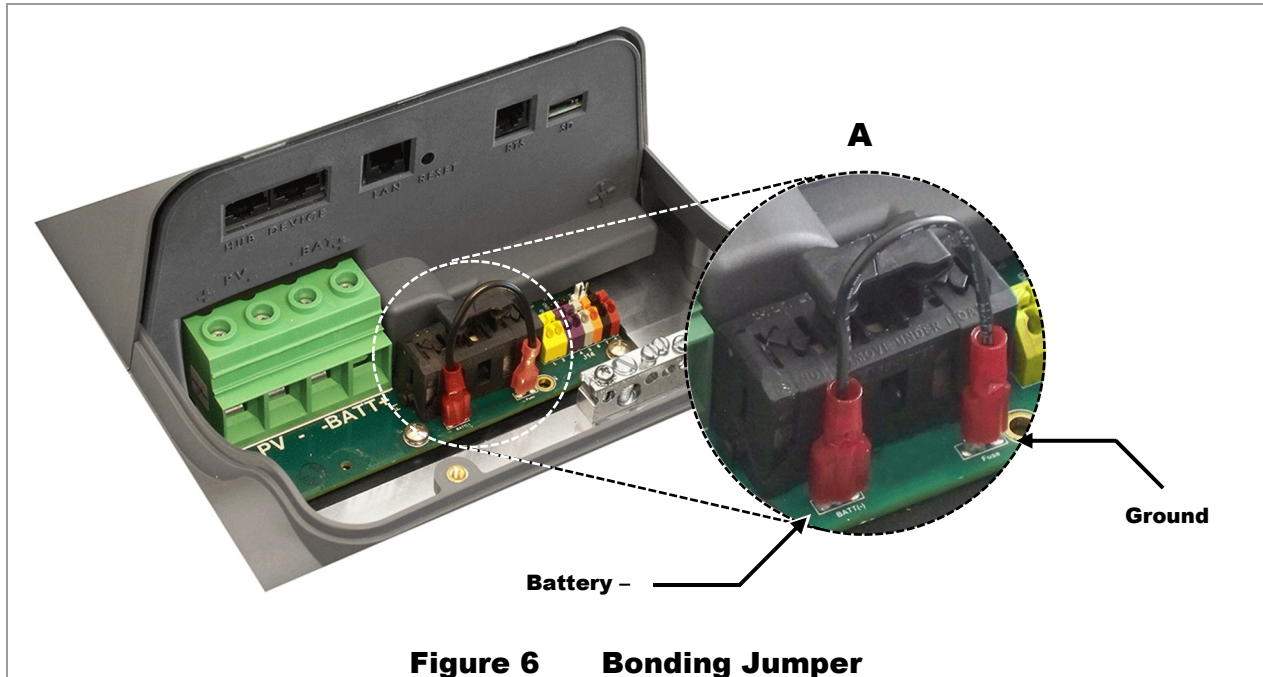


Figure 6 Bonding Jumper

Positive-Ground Systems

The FLEXmax 100 has several critical requirements when used in a positive-ground system.

- The internal GFDI function cannot be used. However, make certain to leave the GFDI fuse in place.
- Ensure neither PV conductor is grounded. The battery conductor is the only item to be grounded.

Take these additional steps.

- Remove the bonding jumper wire (item **A** in Figure 6).
- Establish an external positive-to-ground bond. The controller does not provide this bond.

Several other requirements must be met to maintain NEC compliance.

- Install a dual-pole PV input circuit breaker to protect both the positive and negative conductors.
- Install external GFDI protection. (See the GFDI section on page 15.)

Page 22 depicts a positive-ground system. See page 70 for requirements when networking other devices on positive-grounded systems.

Ground Fault Detection and Interruption (GFDI)

If a ground-fault event occurs, the controller's GFDI fuse will open. The FLEXmax 100 GFDI circuit detects continuity across the fuse. Lack of continuity will cause the charge controller to shut down. If the fuse is not initially installed, the controller will be unable to operate. In either case the LED indicators and the system display will show **GFDI Fault**. (See pages 30 and 38.)

If multiple controllers are used on a common system, all but one fuse must be removed. The other controllers will detect the continuity of the remaining fuse. All units will then respond equally to a ground fault. Figure 7 shows how the fuse is removed or replaced.

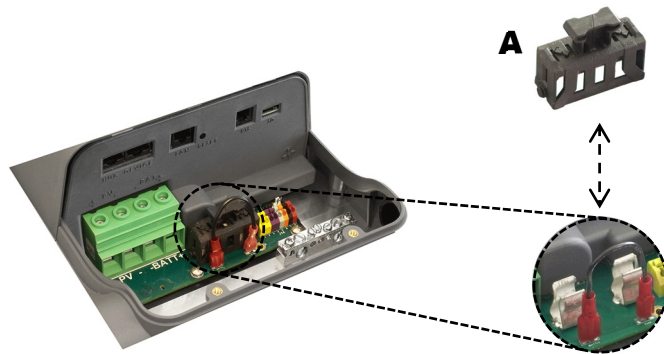
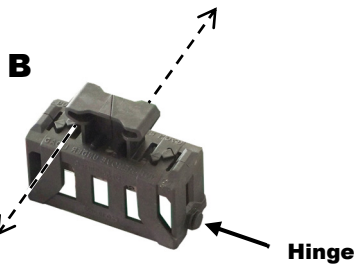


IMPORTANT:

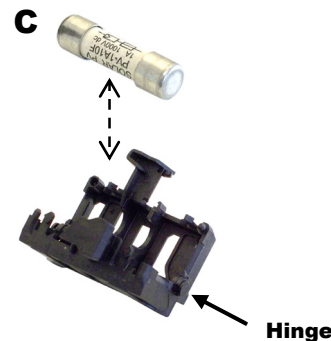
- ❖ Removing the fuse from all controllers (or failing to install it) will prevent the controllers from functioning.
- ❖ Using multiple fuses will keep the FLEXmax 100 GFDI protection from working as specified. It will also establish multiple ground bonds, potentially leading to other error conditions. This will result in noncompliance with NEC or other codes.
- ❖ Removing the ground bonding wire from all controllers will defeat the GFDI function. This is a requirement in positive-ground systems. See the **Ground Bonding** section.

1. To remove the fuse holder **A**, simply grip it tightly by the top handle and pull upward. The fuse and holder will unsnap from the board.

2. To open the fuse holder, push on the two halves of the top handle in opposite directions as shown in **B**. The holder will open on a hinge.



3. The fuse **C** can be easily removed and replaced as needed. Replace with a fuse of the same type.



4. Replace the fuse holder by following these instructions in reverse.

Figure 7 GFDI Fuse

External GFDI





IMPORTANT:

An external ground fault device must also contain the means for PV disconnection. This function is built into OutBack GFDI products.

If alternate PV system grounding configurations or GFDI methods are required, remove the ground bonding jumper wire from all FLEXmax 100 controllers. (See Figure 6 and the **Ground Bonding** section.) Do not remove the GFDI fuses from any controllers. Once the bonding wire has been removed, the external ground fault device can be installed according to its own instructions.

Wiring Size and Requirements

	CAUTION: Equipment Damage
	IMPORTANT:
	Wire sizes must comply with all local and national codes. Input conductors and circuit breakers must be rated at 1.56 times the short-circuit current of the PV array (per NEC). OutBack 100% duty continuous circuit breakers only need to be rated at 1.25 times the short-circuit current.

- Please refer to the NEC and other electrical codes for PV array cable sizing, cable length, and cable ampacity.
- Use #4 AWG (25 mm²) wire (minimum) for the output between the FLEXmax 100 and the battery bus bar conductors. Smaller cables can reduce performance and possibly damage the unit.
- The output can accept conductors up to #2 AWG (35 mm²). Larger conductors will reduce losses and ensure highest performance of the FLEXmax 100. Use 90°C copper wire.
- The maximum permitted conductor size for connection to the grounding wire terminal block is #6 AWG (16 mm²). Use 90°C copper wire.
- Install properly sized overcurrent protection devices. The minimum AIC (amps interrupting capacity) rating required is 1125 Adc.
- The largest PV array must have a rated short-circuit current of 64 amps or less under STC (Standard Test Conditions). The output current limit of the FLEXmax 100 is 100 amps.
- DC battery overcurrent protection must be used as part of the installation. OutBack offers both circuit breakers and fuses for overcurrent protection.

Circuit Breaker Size and Requirements

The input (PV) and output protective devices must be sized according to the installation requirements. OutBack offers a range of circuit breakers to meet these requirements.

Input Circuit Breakers



- PNL-40-300VDC 40 amp single pole
- PNL-40D-300VDC 40 amp double pole
- PNL-60-300VDC 60 amp single pole
- PNL-60D-300VDC 60 amp double pole
- PNL-80-300VDC 80 amp single pole
- PNL-80D-300VDC 80 amp double pole

Output Circuit Breakers

- PNL-100-300VDC 100 amp single pole
- PNL-125-300VDC 125 amp single pole
- PNL-100-300VDC 100 amp single pole with plastic shield
- PNL-125-300VDC 125 amp single pole with plastic shield



NOTE: The plastic shield provided with PNL-100-300VDC and PNL-125-300VDC provides important insulation between devices. Install this shield before installing multiple adjacent circuit breakers. Do not throw this shield away.

Physical Requirements and Conduit

	<p>IMPORTANT: Conduit hubs must connect to the conduit before connecting to the FLEXmax 100.</p>
	<p>WARNING: Burn Hazard The heat sink can become hot when the charge controller is operating. Use caution when touching it during operation.</p>

- All wire lugs and ground terminals are to be tightened to a torque value of 4 Nm (35 in-lb).
- If installing in a wet location, any conduit hubs must comply with the requirements of UL 514B.
- Run positive and negative cables side by side.
 - ~ Tie or twist cables together as much as possible to allow the inductive currents to cancel.
 - ~ Ensure paired cables pass through the *same* knockout and conduit fittings.

PV and Battery Terminals

	<p>WARNING: Shock Hazard When a PV array is exposed to light, it immediately generates a voltage. Make sure all DC circuit breakers are OFF (open) BEFORE making any wiring connections. Open both the battery disconnect devices and the array disconnect devices to ensure isolation of the controller. Use a DVM to check for voltage on all wires.</p>
	<p>CAUTION: Equipment Damage Each FLEXmax 100 requires its own PV array. DO NOT PARALLEL PV+ and PV- TERMINALS OF MULTIPLE CONTROLLERS ON THE SAME ARRAY!</p>

The negative (–) **PV** and negative (–) **BAT** terminals are connected internally. Only one wire is needed to connect to the negative (–) wire lugs if the negative (–) **PV** and **BAT** conductors are connected at the negative bus bar. See Figure 14 on page 22 for an example.

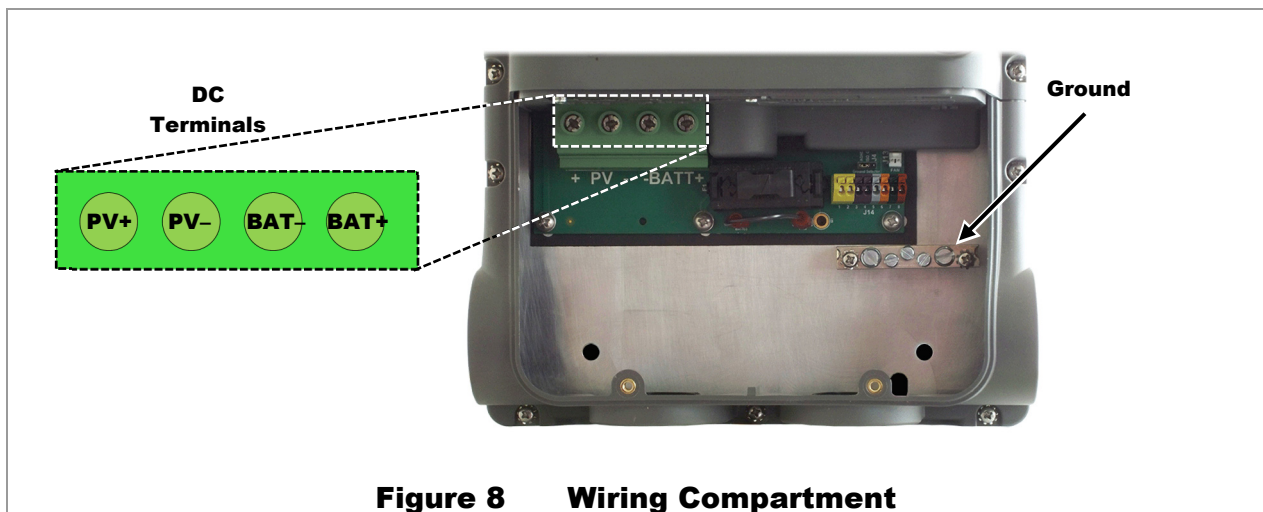
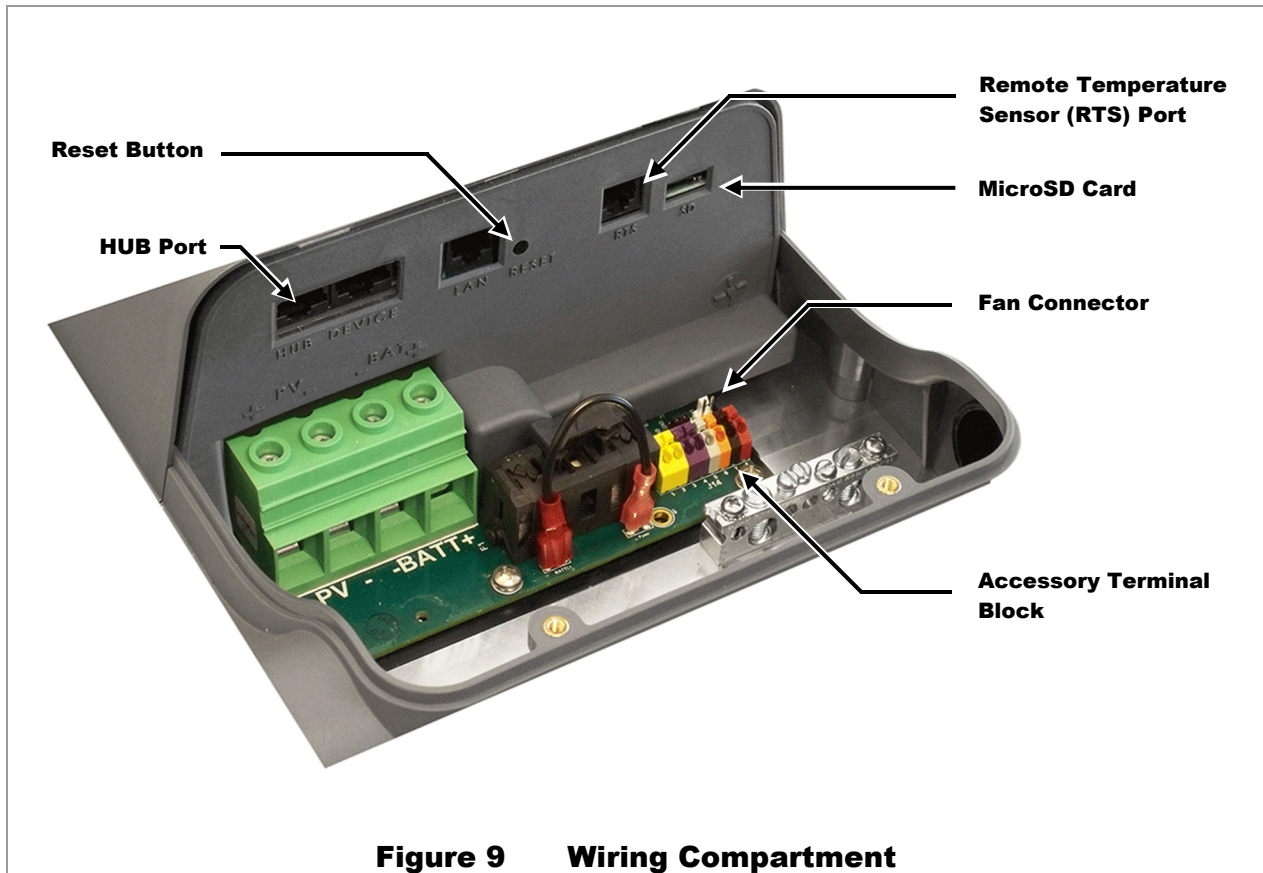


Figure 8 Wiring Compartment

See Figure 14 through Figure 16 beginning on page 22 for sample wiring diagrams.

Accessory Terminals and Ports



Reset Button

This button is used for several functions, including updating the FLEXmax 100 firmware. See page 53.

HUB Port

This is an RJ-45 port for a CAT5-style cable to connect OutBack system displays or the HUB communications manager.

Device and LAN Ports

These ports are not currently active. These ports can be activated in the future using firmware updates.

Remote Temperature Sensor Port

An optional battery Remote Temperature Sensor (RTS) is recommended for accurate battery charging.

When the system includes an OutBack MATE3s system display, a HUB Communications Manager, and multiple devices, only one RTS is needed. The RTS should be connected to the port on the FLEXmax 100. The system display gives this port the highest priority and will communicate compensation values to all other devices.

Specialized temperature compensation is available. See page 43 for more information.

SD Card

When enabled, the microSD card inserted in the slot will record operational status data about the system. The FLEXmax 100 will record data to the microSD card up to the limit of the card. (It has been tested with microSD cards up to 16 GB.) If the card's capacity is exceeded, the data will begin to be overwritten starting with the oldest first.

The microSD card can also be used to update the FLEXmax 100 firmware. See page 53.

Fan Connector

This is the connection for the FLEXmax 100 cooling fan. See page 10.

Accessory Terminal Block

This block of terminals has connections for the **Aux** output, for the Battery Sense function, and for the Rapid Shutdown function. The terminals accept wire from #16 AWG to #24 AWG.

Press on the indented area **A** with a narrow tool to unlock each opening while inserting the wire in **B**. The wire should be inserted at approximately a 45° angle (perpendicular to the opening).

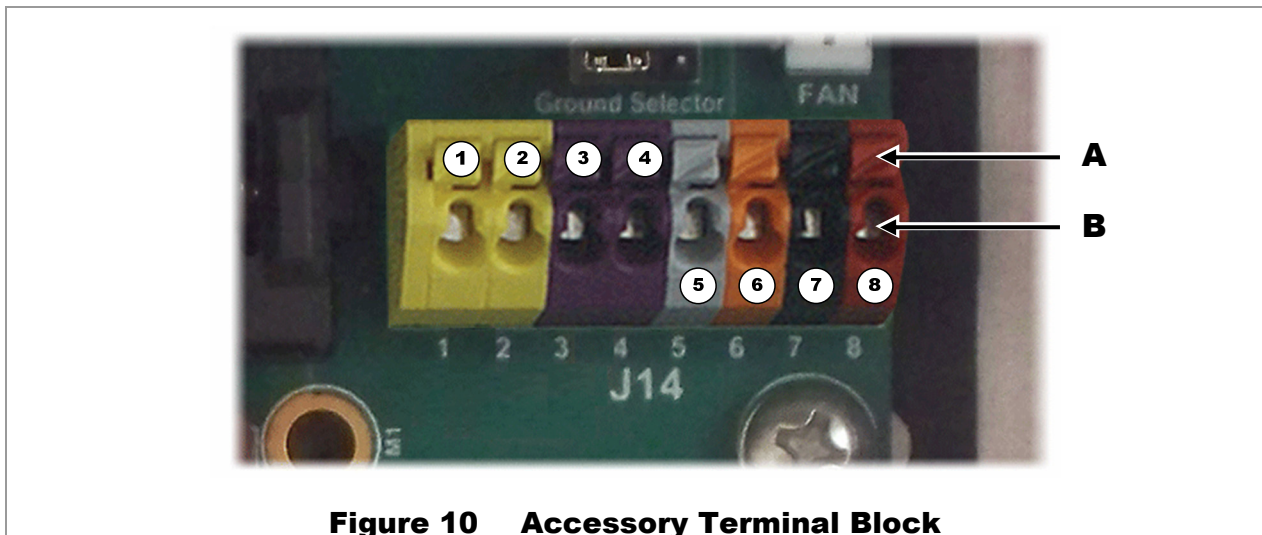


Figure 10 Accessory Terminal Block

Rapid Shutdown Terminals

Terminals **1**, **2**, **3**, and **4** are used for the Rapid Shutdown function. In an emergency, a responder may need to quickly place the PV system in a de-energized state. These terminals can receive Rapid Shutdown commands to quickly shut down the FLEXmax 100. Multiple controllers can be connected in parallel on a single Rapid Shutdown circuit. See page 24 for more discussion of the Rapid Shutdown function, including hookup diagrams.

If an OutBack system display is present, the Rapid Shutdown function will deliver a **Fault Input Active** error message (see page 38).

AUX Terminals

The **Aux** (Auxiliary) output is a small power supply that provides a 12 Vdc output current to an isolated load. The Aux output can respond to many criteria and control many functions. These include cooling fans, vent fans, load diversion, fault alarms, and automatic generator control. The **Aux** can only control one function at a time. Examples of **Aux** applications are shown in Figure 11 and Figure 12 on the next page. See page 45 for a complete description of **Aux** functions and programming.

Installation

Aux terminals **5** and **6** are the **Aux** output – and + terminals. These terminals are colored gray (–) and orange (+) for easy reference. The terminals can supply up to 250 mA at 12 Vdc (3 W). This circuit contains electronic overcurrent protection, which resets after being overloaded. No additional fuses are required for **Aux** terminals.

The **Aux** indicator illuminates when the output becomes active. (See page 30 for a description of the LED indicators and their functions.)

Examples of **AUX** wiring

In this example, the **Aux** output directly drives a 12-volt vent fan. The – and + wires on the fan are connected to **Aux** terminals **5** and **6**, the **Aux**– and **Aux**+ terminals.

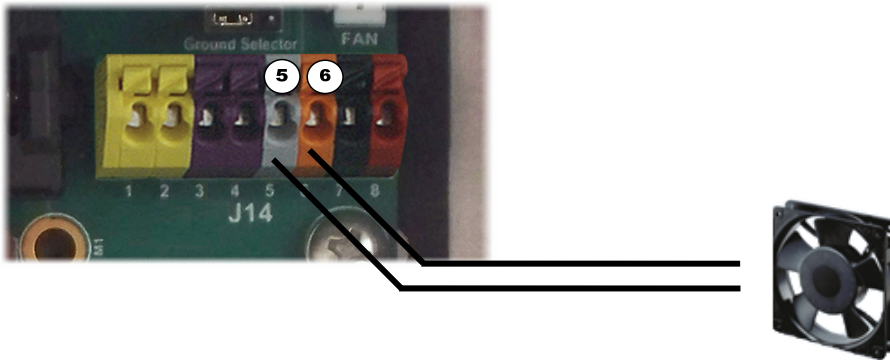
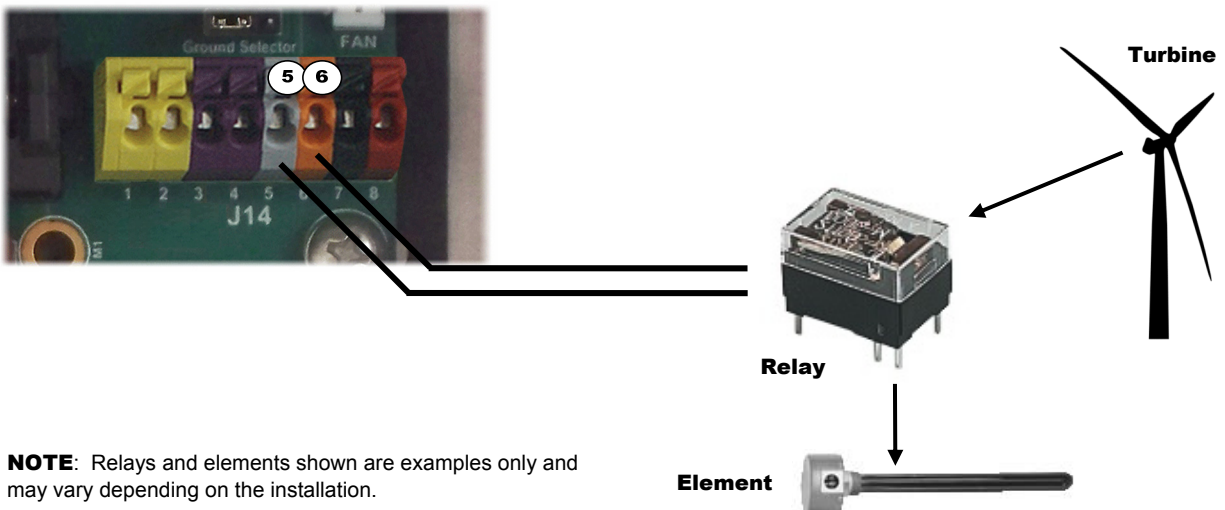


Figure 11 **AUX Vent Fan**

In this example, the **Aux** drives a relay that diverts wind power. The relay's coil is connected to **Aux** terminals **5** and **6**, the **Aux**– and **Aux**+ terminals. When the **Aux** output closes the relay (based on battery voltage), the relay diverts excess power to a water heating element.



NOTE: Relays and elements shown are examples only and may vary depending on the installation.

Figure 12 **AUX Diversion Control**

Battery Sense Terminals

The remote Battery Sense terminals are used for accurate voltage monitoring. These terminals connect directly to the batteries. Using the controller's main battery cables for voltage sensing is less accurate. This is due to voltage rise caused by charging currents on the battery conductors.

Aux terminals **7** and **8** are the – and + terminals for the Battery Sense function. These terminals are colored black (–) and red (+) for easy reference. A twisted-pair cable is recommended. (See page 19 for wire sizes.)



IMPORTANT:

The MATE3s system display shows the overall system voltage as measured at the battery terminals of various devices. (See Figure 26 on page 35.) This voltage is used for generator starting and other functions.

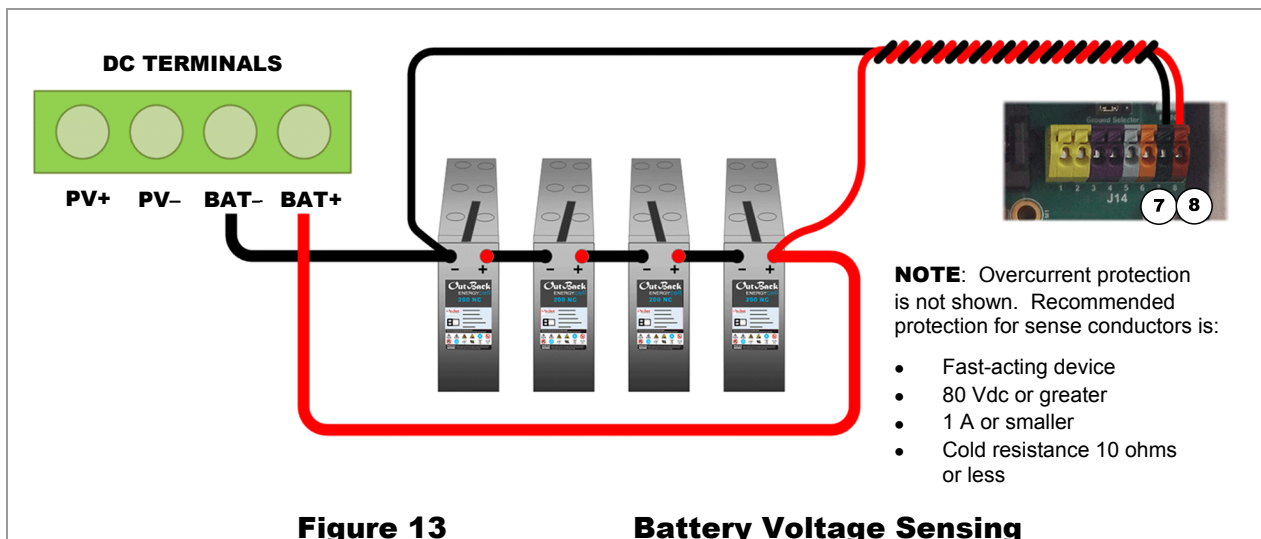
- ❖ If no other devices are present, it will show the reading of the FLEXmax 100. Unless:
- ❖ If OutBack inverters are present, the inverter voltage replaces the FLEXmax 100 as the system voltage reading. Unless:
- ❖ If the FLEXmax 100 Battery Sense terminals are in use, this reading replaces the inverter or the regular charge controller readings as the system voltage. Unless:
- ❖ The FLEXnet DC Battery Monitor is the highest priority and will replace the Battery Sense reading as the system voltage.

The Battery Sense reading is still shown on the **Charge Controller** screen. (See Figure 27 on page 36.) This reading is still used to adjust the FLEXmax 100 charging.

This function operates automatically when it detects a voltage within 2 volts of the battery voltage reading at the charge controller's main terminals. If the reading varies by more than 2 volts, the Battery Sense function is disabled. The assumption is that the terminals are not connected. (If the terminals are connected, there may be a wiring problem.)

The Battery Sense function has several advantages apart from accurate battery readings.

- The more accurate charging may increase battery life.
- A single set of readings can be used by multiple FLEXmax 100 controllers.
- Conflict between controllers due to differing readings is eliminated.
- The need for calibration is eliminated. If Battery Sense is not in use, the user can calibrate the battery meter at the charge controller's main terminals. See page 50 and the system display literature for more information. (If Battery Sense is in use, calibration changes are not needed and will have no effect.)



Wiring Diagrams

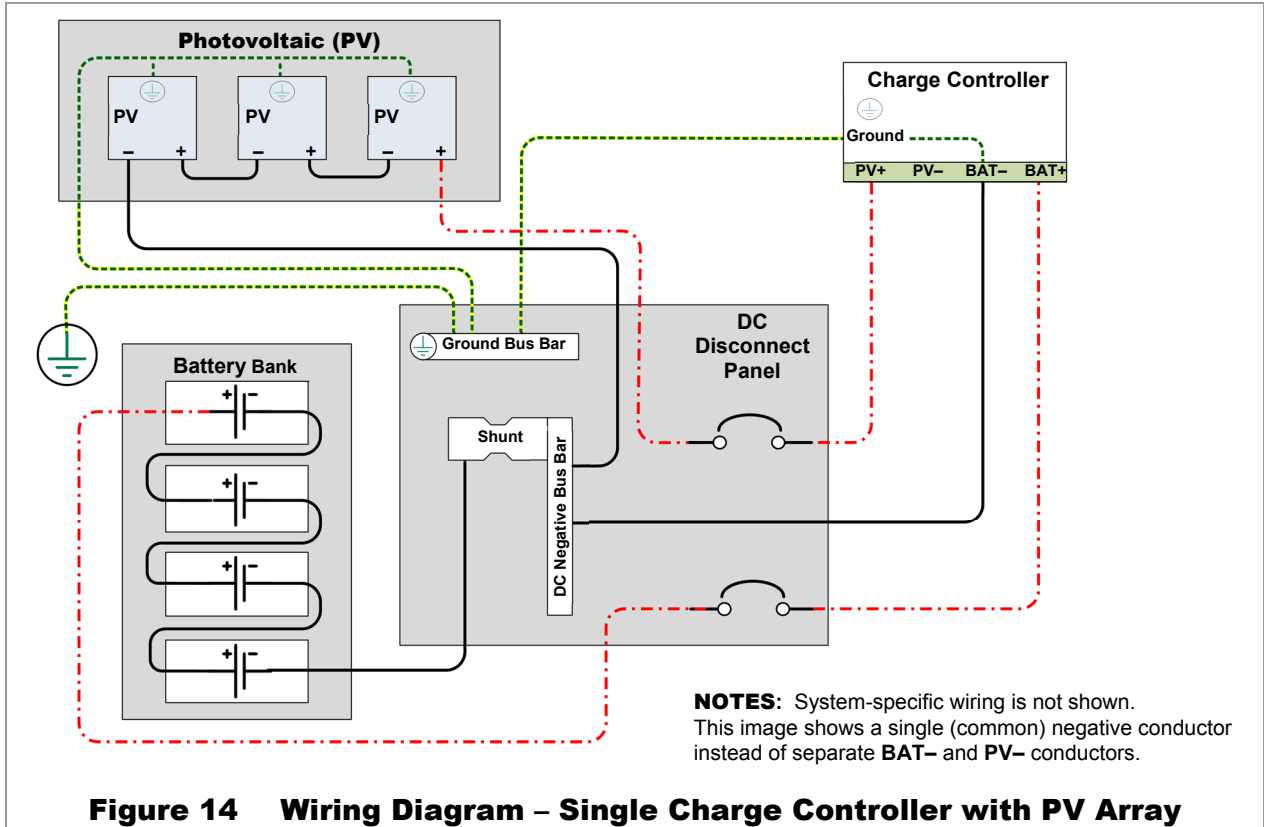


Figure 14 Wiring Diagram – Single Charge Controller with PV Array

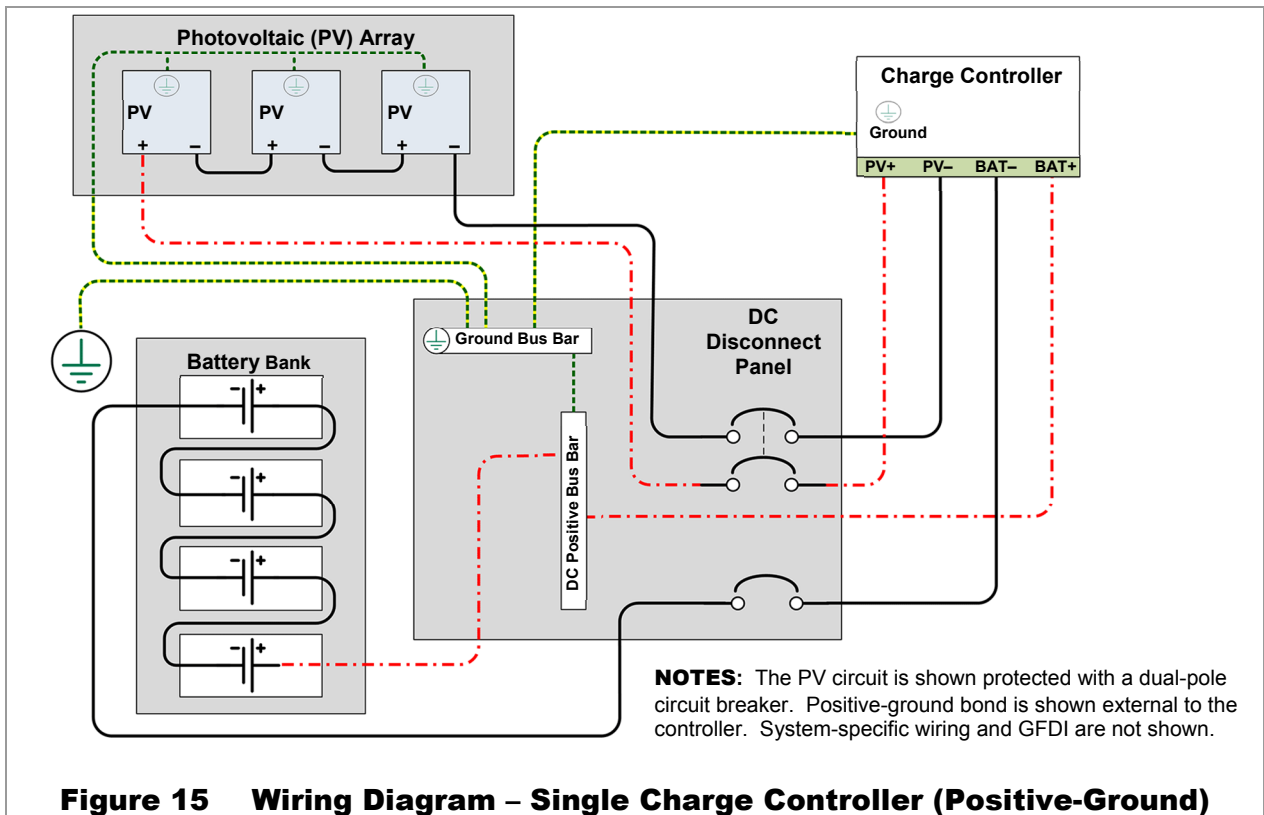


Figure 15 Wiring Diagram – Single Charge Controller (Positive-Ground)

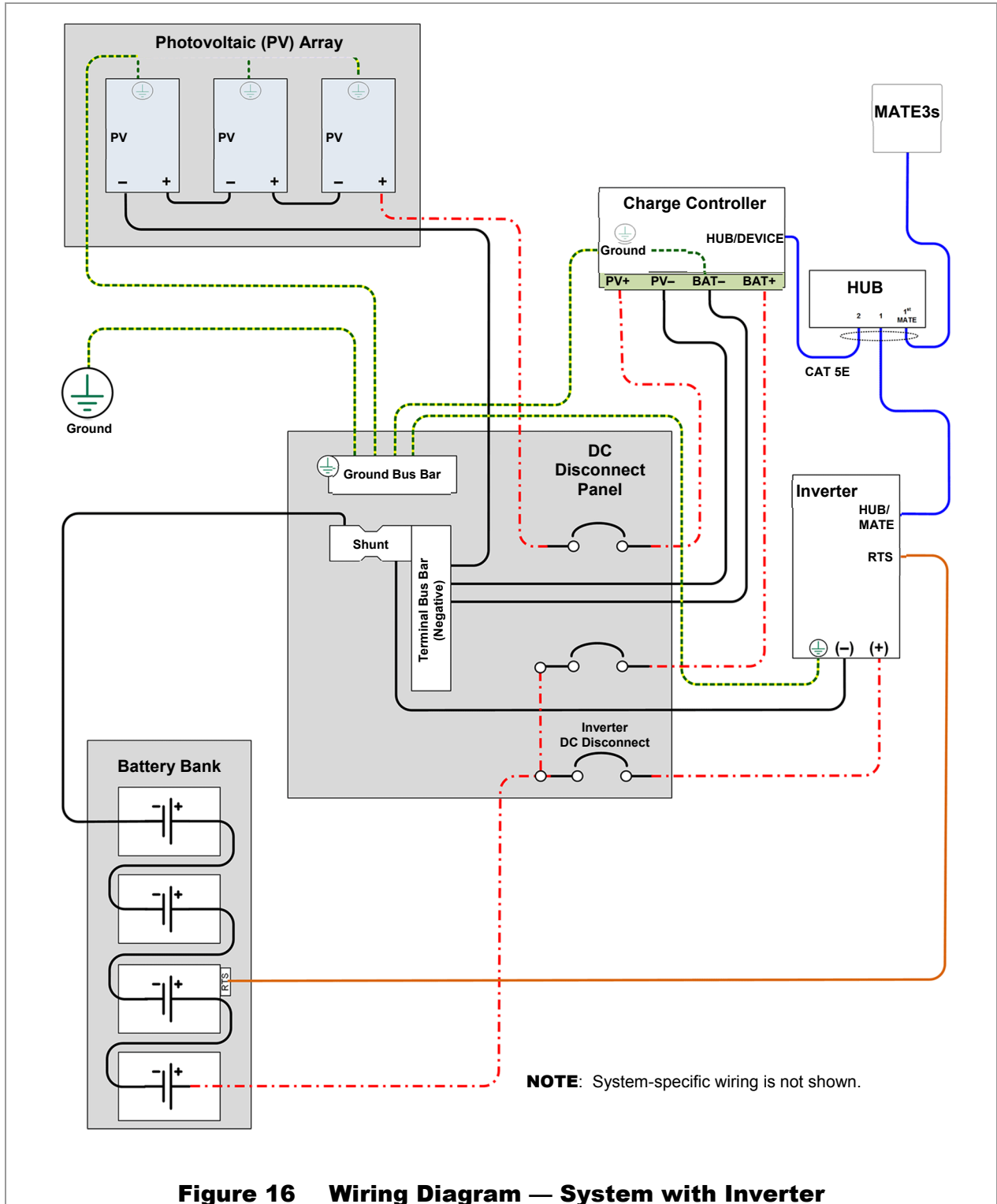


Figure 16 Wiring Diagram — System with Inverter

Wiring the Rapid Shutdown Terminals

NEC 690.12 states "PV systems installed on or in buildings shall include a rapid shutdown function to reduce shock hazard for emergency responders".

The Rapid Shutdown terminals can make connections to the RSI (Rapid Shutdown Initiator) product, which is part of the OutBack ICS Plus system. A similar rapid-shutdown device may also be used.

A single wire is run from one of the yellow terminals (**1** or **2**). A second single wire is run from one of the purple terminals (**3** or **4**). Terminals **1** and **3** are the most commonly used. On the OutBack RSI these wires are connected to the **AUX RSI COMMAND /STATUS OUTPUT** contacts. (See the ICS Plus *Owner's Manual* for more information.)

Note that for simplicity, Figure 17 and Figure 18 do not show terminals **5** through **8**.

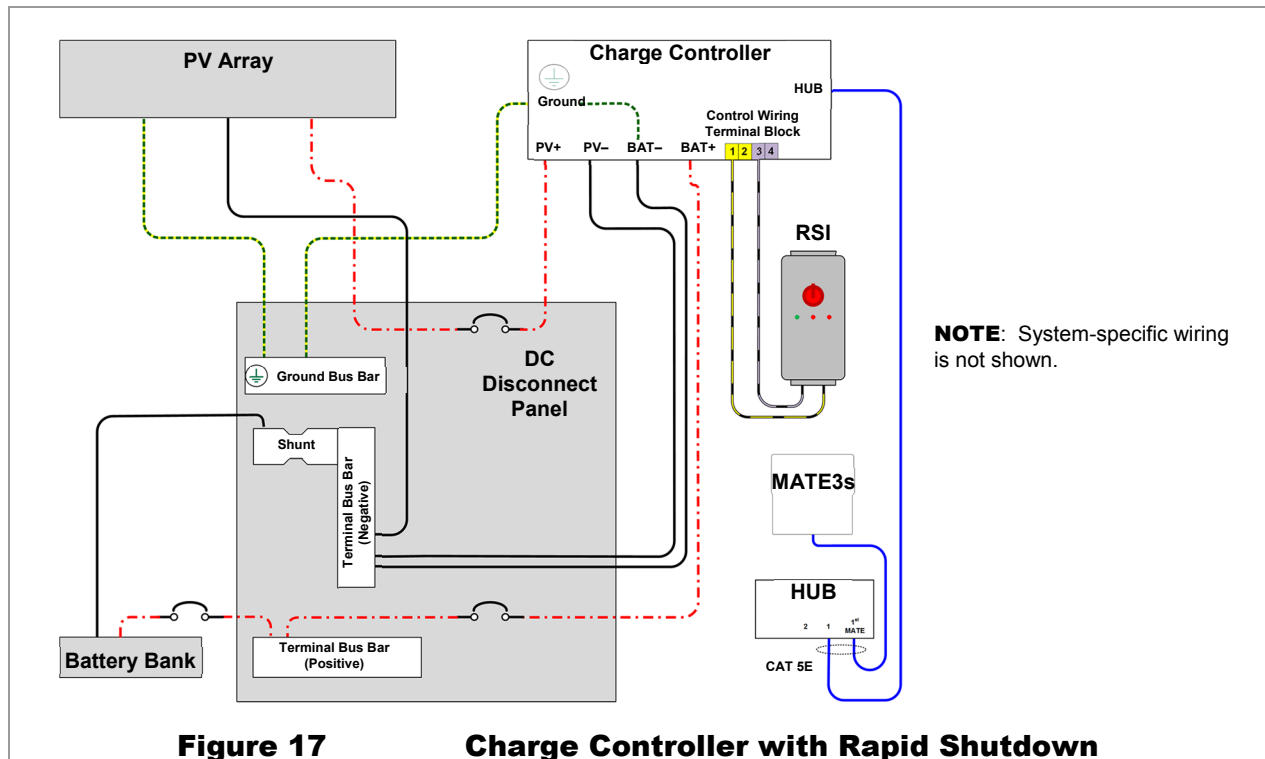


Figure 17 Charge Controller with Rapid Shutdown

In Figure 17, a wire has been run from terminal **1** to one of the RSI terminals. A wire has also been run from terminal **3** to the other RSI terminal.

The terminals detect electrical continuity, which is present while the RSI contacts remain closed. If a rapid shutdown event occurs (the RSI switch is thrown and the PV is disconnected), these contacts will open and the circuit will detect the loss of continuity. When the controller senses loss of PV input (less than 20 Vdc), it will shut down. All LED indicators will flash twice and then turn off. (See pages 30 and 55.) If the system display is present, it will deliver a **Fault Input Active** error message. (See page 38.)

Any device with normally-closed contacts can work with this function. If more than one device is used, all contacts must be wired in series so that any one device will shut down the controller.

If a rapid-shutdown device is not installed, this function should be disabled. This is performed by directly shorting terminals **1** and **3** with a small jumper wire.



IMPORTANT:

The FLEXmax 100 will not function unless either the disabling jumper, the OutBack RSI, or a similar normally-closed device is installed. Initial power-up will result in a Rapid Shutdown signal. (See page 55.)

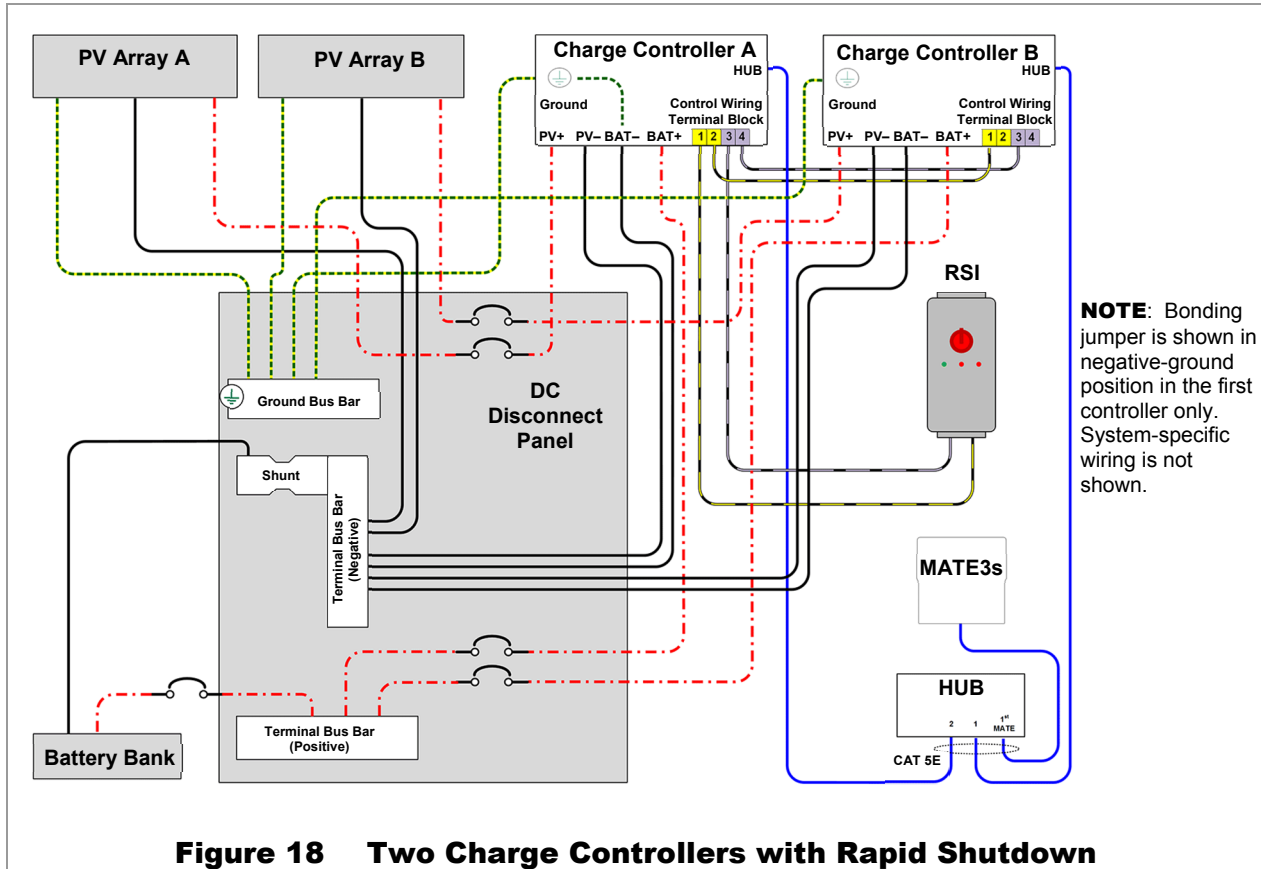


Figure 18 Two Charge Controllers with Rapid Shutdown

If multiple charge controllers are in use, they can be paralleled so that all controllers use a common rapid-shutdown circuit. Terminals **2** and **4** are a parallel set of connections to terminals **1** and **3**.

- In Figure 18, Charge Controller A terminal **1** is wired to one of the RSI terminals. Terminal **3** is wired to the other RSI terminal.
- In Figure 18, Controller A also shows terminals **2** and **4** wired to Controller B terminals **1** and **3**.
 - ~ This places the Rapid Shutdown circuits on both controllers in parallel. It allows Controller B to sense the same conditions as Controller A so that it will react accordingly.
 - ~ If a third controller is present, its terminals **1** and **3** should have wires connecting to terminals **2** and **4** on Controller B, and so on.
 - ~ Additional controllers can be added as needed.

The terminals detect electrical continuity, which is present while the RSI contacts remain closed. If a rapid shutdown event occurs (the RSI switch is thrown and the PV is disconnected), these contacts will open and the circuit will detect the loss of continuity. When the controller senses loss of PV input (less than 20 Vdc), it will shut down. All LED indicators will flash twice and then turn off. (See pages 30 and 55.) If the system display is present, it will deliver a **Fault Input Active** error message. (See page 38.)

NOTE: To reset the controller after a rapid shutdown, simply reset the shutdown device.

Power Up

To power up the controller:



1. Connect battery power to the controller by closing the disconnect.
2. Connect PV power to the controller by closing the disconnect. See **Initial Operation** on page 27.

The FLEXmax 100 uses power from the battery bank to operate. The battery voltage must be at least 15 volts or higher to power up the charge controller.

When battery power is detected, the charge controller will flash all LED indicators in sequence as it performs a self-test.

The blue **CHARGING** indicator will then flash to show the nominal system voltage that was detected. Beginning with a 24-volt system, each flash indicates an increment of 12 volts. (Two flashes = 24 Vdc, three flashes = 36 Vdc, and so on.)

See page 29 for descriptions of all LED indicators.

	<p>IMPORTANT:</p> <p>The PV array voltage is automatically detected upon connection. The PV array voltage must never exceed 300 V_{oc}.</p>
	<p>NOTE:</p> <ul style="list-style-type: none">❖ The charge controller automatically senses the nominal battery voltage upon connection. Once set, it retains the nominal voltage setting. Following any type of shutdown or disconnect, it will return to operation automatically.❖ The FLEXmax 100 should be restored to factory default settings (see page 50) and the nominal voltage should be reset (see below) any time the system is substantially revised or the controller is relocated.

Setting the Nominal Voltage

Upon initial power-up, the FLEXmax 100 will sense the battery voltage and use this reading to determine the nominal system voltage — a battery bank that is nominally between 24 and 48 volts DC.

The batteries must be within the appropriate voltage range for the controller to take the correct reading. A severely discharged 48-volt battery bank, for example, could read as a 36-volt bank and cause the controller to charge inappropriately (or not at all).

The ranges of detection for each nominal battery voltage are:

- 24-volt system — above 15.7 Vdc to 31.4 Vdc
- 36-volt system — above 31.4 Vdc to 43.2 Vdc
- 48-volt system — above 43.2 Vdc to 62.8 Vdc

Normally the nominal system voltage is retained. If the FLEXmax 100 is disconnected from the batteries or otherwise loses power, upon a new power-up it will continue using the nominal voltage and settings determined previously.

If it is necessary to change the nominal voltage:

1. Reset the FLEXmax 100 to factory default settings as described in the next section.
2. Remove all sources of power (PV and battery) from the FLEXmax 100 and then reconnect battery power.

The controller will sense the battery voltage and use this reading to determine the new nominal system voltage. This will not occur until the power is turned off and then on again.

Initial Operation

When the PV input circuit breaker is turned on, the FLEXmax 100 automatically detects the PV input voltage. It then enters the “Wakeup” state (see page 34) and prepares to charge the batteries by tracking the maximum power point of the PV array.

During the initial tracking, the input PV source is gradually loaded from the open-circuit voltage (V_{oc}) to one half of the V_{oc} . Within this range, the FLEXmax 100 seeks the maximum power point. The amount of time required before starting operation is dependent on the module type, ambient temperature, and the amount of sunlight directly on the PV array. Normally, the FLEXmax 100 starts in the morning within a few minutes of the PV array being exposed to sufficient direct sunlight.

Once the controller begins maximum power point tracking, it will enter a three-stage battery charging cycle. This cycle can be observed with the controller’s LED indicators. (See page 29.) If a system display is available, it is possible to observe the specific charging stage, mode messages, and readings of the charge controller.

Resetting to Factory Defaults

To reset programmed items to the factory default settings:

1. Remove all sources of power (PV and battery) from the FLEXmax 100.
2. Press and hold the **EQUALIZE** switch (see page 8) while reconnecting battery power.
3. Continue holding the **EQUALIZE** switch. After approximately 10 seconds, the **STATUS** indicator will blink green rapidly. Continue holding the switch until the **STATUS** indicator begins blinking amber more slowly. When the resetting process is complete, the **FAULT** indicator (red) will illuminate.
4. Release the **EQUALIZE** switch and disconnect the batteries.

The system display can be used to reset the FLEXmax 100 to its factory default settings. See page 50 for more information.



Status and Information

LED Indicators

The FLEXmax 100 charge controller has no graphical display. It is equipped with four LED indicators.

Table 2 LED Indicators

Indicators	Pattern	Controller Status	Voltage
CHARGING	—	Off = less than 10 W PV available	Battery rest
	— — — —	Bulk, Equalize, or GT Mode	
	- - - -	Absorption	
	Float	Float
STATUS	— — — —	Bulk or Absorption	≥ 1.91 Vpc
	— — — —	Float	
	- - - -	GT Mode	
	- - - -	Battery Discharge	< 1.91 Vpc
	- - - -	Critical Battery Discharge	< 1.75 Vpc
AUXILIARY	— — — —	Equalize	$\leq EQ$
	— — — —	AUX Active	
FAULT	— — — —	Ground Fault Shutdown or other fault	

All off (with PV power available) = Rapid Shutdown



IMPORTANT:

The LED indicators do not necessarily tell the amount the controller is actively charging. The **CHARGE** indicator may still indicate Absorption and the **STATUS** indicator may indicate rising battery voltage, even if another charging source is doing most of the work.



NOTE:

The LED indicators are intended as pointers rather than exact messages. See the next page for a more specific description of each indicator. Consult the system display for more information on controller status. (See page 35.)

1 CHARGE (Blue):

Illuminates when more than 10 watts of PV power is available. It is solid or flashing depending on the charging stage. The system display represents these stages as operating modes in the **STATUS** menu. See page 36 for a list of modes. See page 65 for a description of charging stages.

Solid: Bulk or Equalization charging.

- Accompanied by **STATUS** indicator 2. See below for colors.

Flashing: Absorption or Float charging.

- Accompanied by amber **STATUS** indicator 2 in Absorption stage.
- Accompanied by green **STATUS** indicator in Float stage.
- Will continue flashing in these modes even if less than 10 watts is available.
- The **STATUS** indicator flashes during power-up to indicate nominal voltage. (See page 26.) It may briefly illuminate at other times when not charging. (See Table 4 on page 34.)

Off: Less than 10 watts of PV power is available.

2 STATUS (Tri-color Red, Green, or Amber):

Indicate either battery voltage or charger status. See Table 2 on page 29.

NOTE: Amber is a mixture of the red and green colors.

Amber (solid): The battery voltage is equal or greater than 1.91 volts per cell (Vpc).

- Usually indicates Bulk or Absorption stage.
- Accompanied by solid blue **CHARGE** indicator 1 in Bulk stage.
- Accompanied by flashing **CHARGE** indicator 1 in Absorption stage.

Green (solid): The unit has entered Float stage.

- It will remain green regardless of the battery voltage until it falls below 2.08 Vpc. This will trigger a new charge cycle.
- Accompanied by flashing blue **CHARGE** indicator 1.

Green (flashing): Indicates **Grid-Tie** mode. See page 44.

Amber/Green (alternating): Equalization mode.

- Accompanied by solid blue **CHARGE** indicator 1.
- May also flash amber/red. (See pages 33 and 66.)

Red (solid): The batteries are less than 1.91 Vpc. This indicates that the batteries are severely discharged.

Red (flashing): The batteries are less than 1.75 Vpc. This indicates that the batteries are critically discharged.

- These states do not indicate the charging stage. It may still be shown by the blue **CHARGE** indicator.

3 AUX (Yellow):

- Solid:* The AUX output is active.

4 ERROR (Red):

- Solid:* The GFDI circuit has shut down the charge controller. See page 15 for more information. If the system display is present, it will deliver a **GFDI Fault** error message (see page 38). See Table 7 beginning on page 53 for information on resetting this error.
- Flashing:* This indicator will flash twice to indicate a Rapid Shutdown. See page 19 and 24 for information. All indicators will then go out until the Rapid Shutdown is reset. (See page 25.) If the system display is present, it will deliver a **Fault Input Active** error message (see page 38).

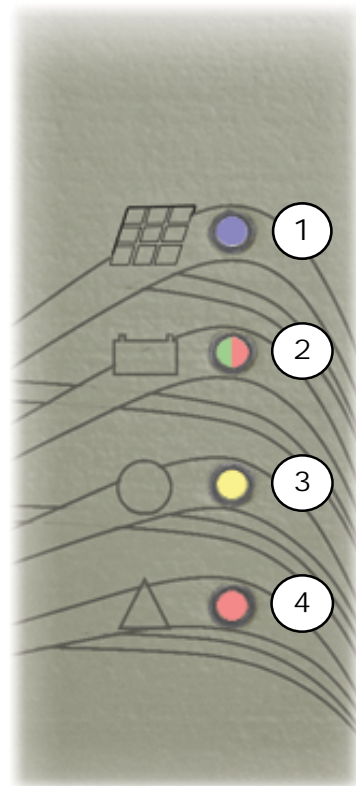
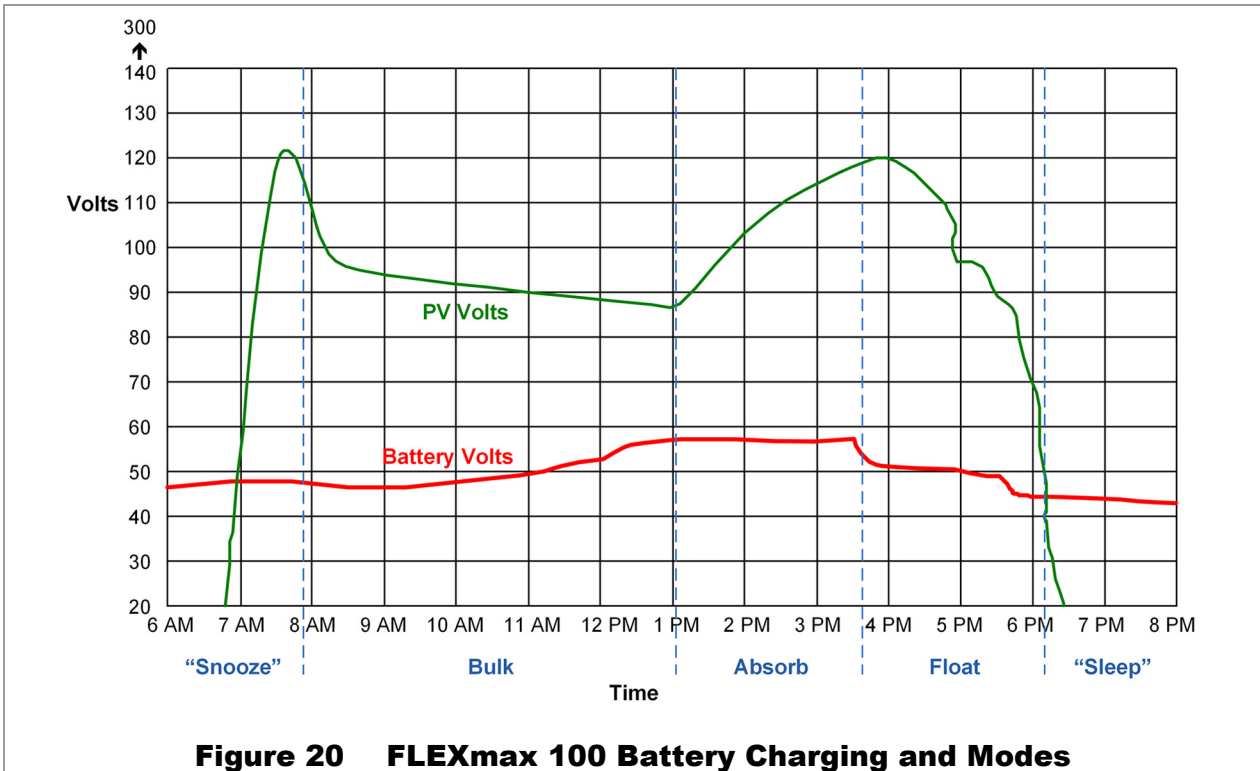


Figure 19 LED Indicators

Modes of Operation

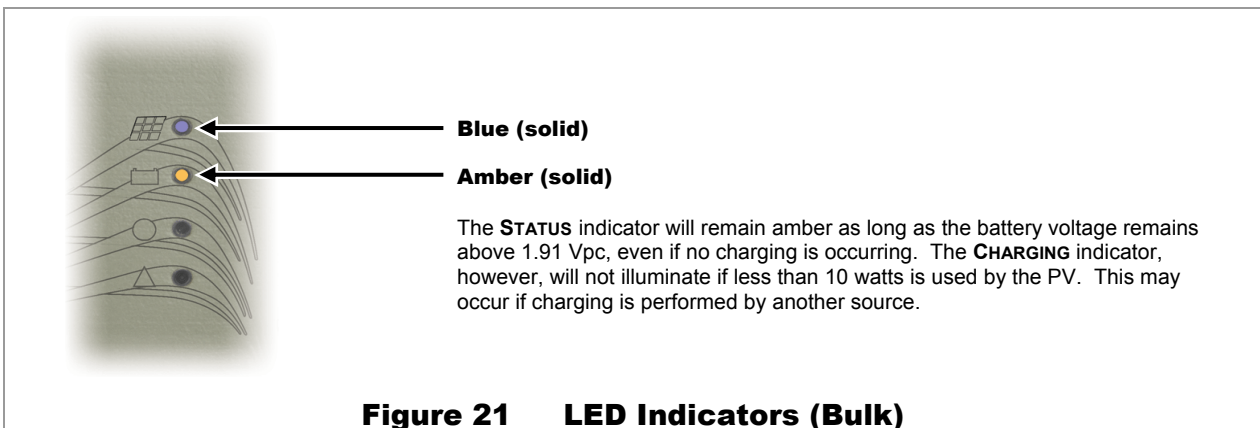
The FLEXmax 100 goes through many states during its operation. Figure 20 shows an example of the various stages of battery charging and several states when the controller is not charging. (The graph in Figure 20 shows a typical day of charging with a nominal 48-volt system. Charging is described in detail on page 67.)

A MATE3s system display has five “mode” messages which represent all states of operation. The following sections use the names displayed by the system display. (See page 36.) These sections describe the controller operation and show the LED indicators illuminated in each mode.



Bulk

This is a Maximum Power Point Tracking mode which harvests the maximum wattage available from the PV array. The controller will drive the battery voltage towards the **Absorb Voltage** set point. Normally the charge controller enters this mode at the beginning of the day or when a new charge cycle begins. The controller may also enter this stage if there is not enough PV energy to maintain a different stage such as Absorption. See page 32 for more information.

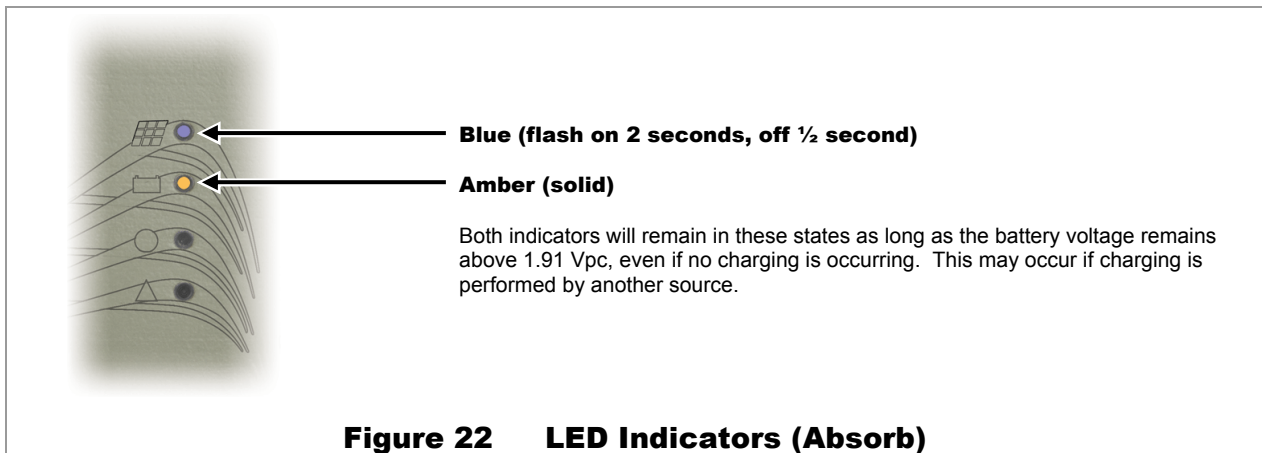


Absorb

The system display shows this message for the Absorption stage of a three-stage cycle. In this stage, the FLEXmax 100 regulates the battery voltage at the **Absorb Voltage** set point. This stage is temperature-compensated. (See page 68.) Absorption is a constant-voltage, variable-current charging stage. It usually involves a tapering current flow. However, it may deliver no current and still display **Absorb** if another source maintains the batteries above the **Absorb Voltage** set point.

While the batteries are held at this voltage, the internal timer counts up from zero toward the **Absorb** time setting. (See pages 36, 42, and 67.) The charger will exit this stage and enter the Float stage if the timer reaches the time limit, or if the **Absorb End Amps** setting is reached. (See page 42.)

The absorption timer is internal to the FLEXmax 100 and is not displayed as a real-time reading. However, the **Absorb** reading shown on page 36 will display the total time spent in Absorption that day.



If the battery voltage drops below the **Absorb Voltage** set point before the **Absorb** time is reached (see page 42), the FLEXmax 100 reverts back to the Bulk charge stage. The system display shows **Bulk** as shown on page 31.

The internal timer may not always begin at zero if the last charge was interrupted or ended early. If the batteries drop below the voltages noted on Table 3, the timer will begin counting down toward zero. This adds to the duration of the next Absorption stage. If the timer reaches zero, it will last for the full duration of the **Absorb** time setting.

Lower voltages will cause the timer to subtract minutes at a faster rate, as shown on Table 3. These voltages indicate a significantly greater battery discharge, requiring a much longer charge cycle.

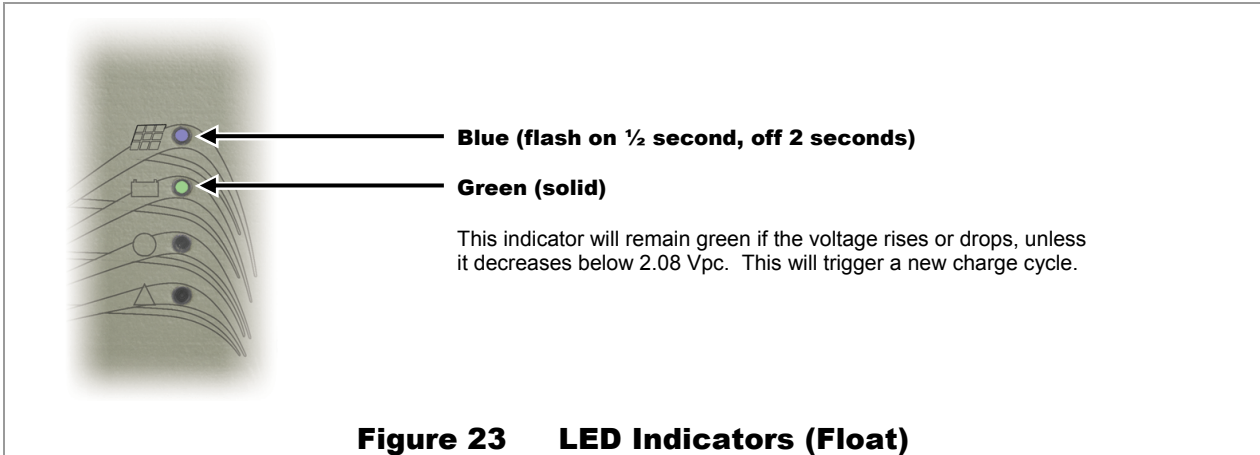
Table 3 Absorption Timer

Battery Voltage	Timer Activity
≥ 24.8 V, 37.2 V, or 49.6 V, and less than the Absorbing voltage	No change.
< 24.8 V, 37.2 V, or 49.6 V	For every minute elapsed, 1 minute is subtracted from the timer
< 24.0 V, 36.0 V, or 48.0 V	For every minute elapsed, 2 minutes is subtracted from the timer
< 23.2 V, 34.8 V, or 46.6 V	For every minute elapsed, 4 minutes is subtracted from the timer.

Floating

The system display shows this message for the Float stage of a three-stage charging cycle. In this stage, the FLEXmax 100 regulates the battery voltage at the **Float Voltage** set point. This stage is temperature-compensated. (See page 68.) Float is a constant-voltage, variable-current charging stage. It usually involves a minimal (maintenance) current flow. However, it may deliver no current and still display **Float** if another source maintains the batteries above the **Float Voltage**.

If the battery voltage drops below the **Float Voltage**, the FLEXmax 100 will employ the MPPT function to draw more power from the PV array. (This may occur if the batteries are powering loads.) If this occurs, the operation may change to constant-current, variable-voltage. The mode will still show **Float**.

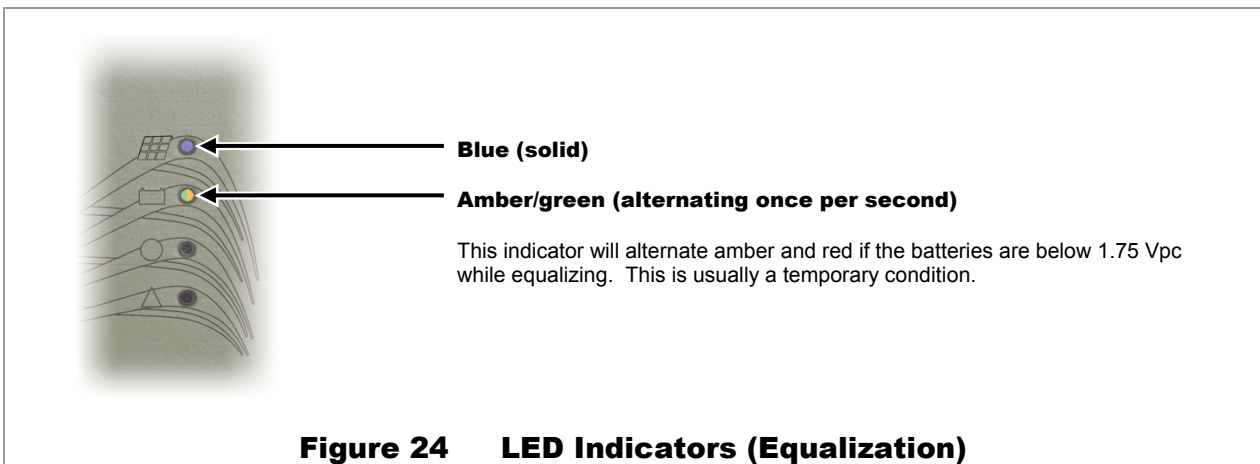


EQ

The system display shows this message if the charger is in a cycle of equalization. (See page 68 for an explanation of equalization.)

Before equalizing, battery loads should be minimized and the battery should be charged so the charge controller can quickly reach the **Equalization Voltage** set point. (See page 44.) Otherwise, the charge controller may have difficulty reaching or maintaining the equalization process.

Equalization is not battery temperature compensated.



Silent

The system display shows the operating mode as **Silent** if the charge controller has stopped charging. This message represents a variety of conditions, many of which are common. For example, **Silent** is shown at night or any period of insufficient light. Table 4 lists the LED indicators and the PV open-circuit voltage which show specific Silent conditions. In these cases, no LED indicators will be illuminated.

However, **Silent** may also appear in the event of an error shutdown. If the mode is **Silent** and the red **FAULT** indicator is illuminated, a ground fault may have occurred. See pages 15 and 55.

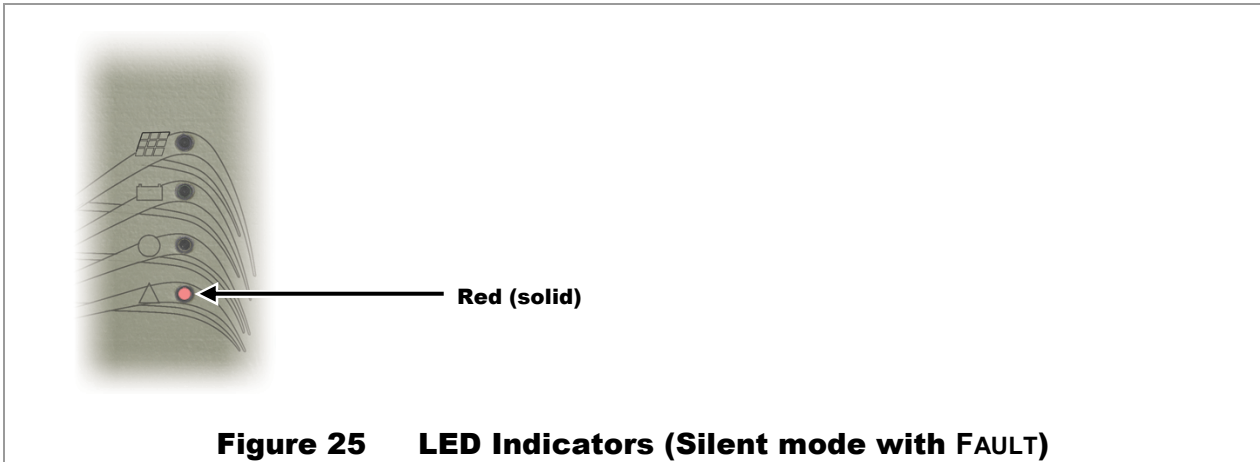
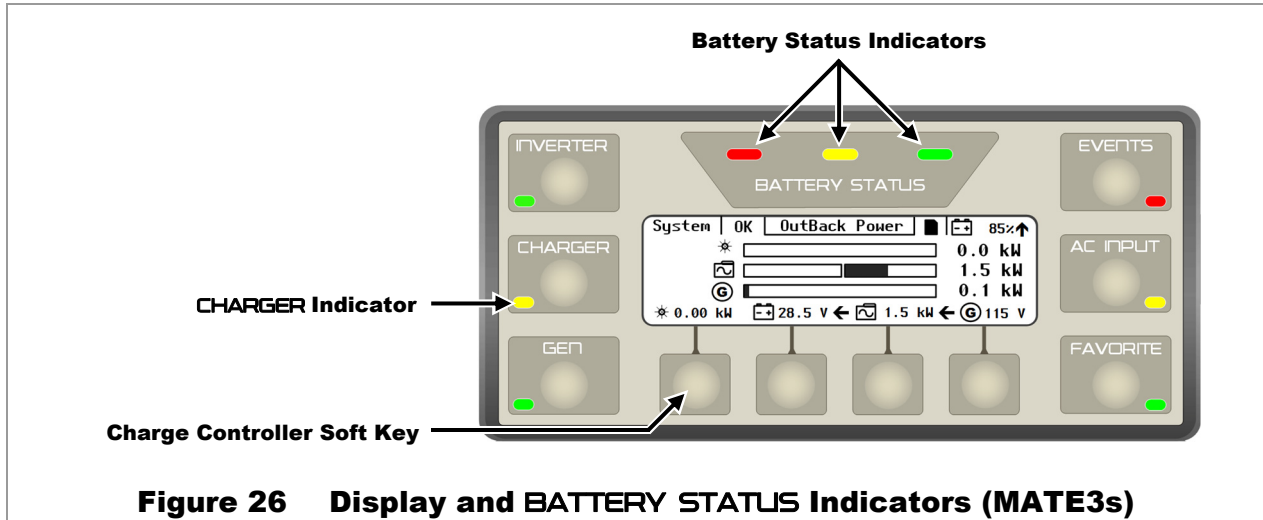


Table 4 Reasons for Silent Mode

CHARGE LED	STATUS LED	FAULT LED	V _{oc}	Other
No	No	No	Below battery	No PV energy or “Sleep” mode. If the V _{oc} is less than battery voltage, the controller is “sleeping”. This is normal at night. The threshold for Sleep mode is settable. See page 43.
			Above battery	Low light or “Snooze” mode. V _{oc} is greater than battery voltage but not enough array current is available for charging. This is normal in the morning, evening, or in heavy clouds (low light). The threshold for Snooze mode is settable. See page 43.
Intermittent	Any	No	Above battery	<p>“Wakeup” mode. The controller has detected more than the required 10 watts, but has not yet begun charging. This condition only lasts a short time. The blue CHARGE indicator may turn on and off briefly while the controller is performing initial power tracking. This can also occur if PV conditions change and the controller has to calculate a new power point.</p> <p>If continuous, this behavior may also indicate an “unloaded output” condition where the batteries have been disconnected from the controller.</p>

MATE3s System Display



The MATE3s System Display and Controller is a display which allows the user to read the operating mode, measurements, and any status messages from the FLEXmax 100 charge controller. It can also change the charge controller’s settings when the default settings are not enough.

Battery Status Indicators

Three LED indicators provide a visual reference to indicate the condition of the battery bank.

- A **GREEN** LED means the batteries have an adequate charge at that time. It does not always mean they are full. If the FLEXnet DC battery monitor is installed, this means the batteries are $\geq 80\%$ State of Charge (SOC).
- A **YELLOW** LED means the batteries are somewhat discharged. If the FLEXnet DC is installed, this means the batteries are $\geq 60\%$ and $\leq 70\%$.
- A **RED** LED means the batteries are greatly discharged and may require attention. If the FLEXnet DC is installed, this means the batteries are $< 60\%$.

Table 5 Battery Status LED Indicators

Color	24 Vdc Unit	36 Vdc Unit	48 Vdc Unit	Battery Status
GREEN	25.0 Vdc or higher	37.5 Vdc or higher	50.0 Vdc or higher	Acceptable
YELLOW	23.0 to 24.9 Vdc	34.5 to 37.4 Vdc	46.0 to 49.9 Vdc	Marginal
RED	22.9 Vdc or lower	34.4 Vdc or lower	45.9 Vdc or lower	Low

NOTES:

- The **BATTERY** LED settings cannot be changed.
- Voltages higher than shown in the **GREEN** row usually means that the batteries are charging.

Charger Indicator

The system display is equipped with several LED indicators denoting status. The **CHARGER** indicator (see Figure 26) will illuminate if the charge controller is delivering more than a minimal amount of charging power to the batteries. It will flash if the charge controller is equalizing the batteries.

NOTE: The **CHARGER** indicator will illuminate for any device on the HUB Communications Manager that is charging, including OutBack inverters. If a FLEXmax 100 charge controller is accompanied by other devices, this indicator may indicate charging by any device, not just that controller.

Charge Controller Soft Key

The system display is equipped with a series of “soft” keys with varying functions. From the **Home** screen, the far left key is designated as the **<Charge Controller>** soft key any time a charge controller is connected. (See page 35.) Pressing it will enter the **Status** menu for the charge controller.

Status Screen

Modes of Operation:

- **Bulk**
- **Absorb**
- **Float**
- **EQ**
- **Silent**

See page 31 for a description of modes.
See page 67 for a description of battery charging.

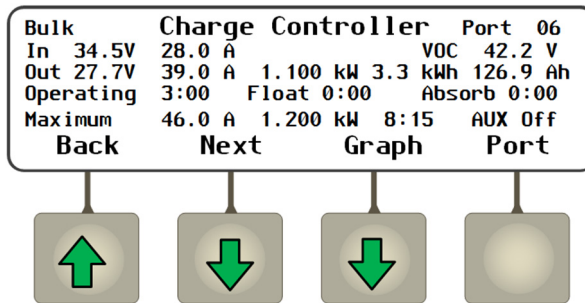
Soft Keys:

<Next> brings up a series of screens with current statistics, totals, and other data. The internal temperatures and any fault messages are also displayed here. These screens are all shown beginning on page 37.

<Graph> brings up a series of screens that plot various charge controller information over time. The graphs include inverter and charger wattage, power imported from an AC source, battery voltage, and others. These screens are all shown beginning on page 40.

<Port> cycles through each device connected to the network. If more than one charge controller is installed in the system, pressing the **<Port>** soft key will cycle through each controller.

<Back> returns to the previous screen.



Screen Items:

- The upper left corner of the screen shows the FLEXmax 100 charge controller’s current mode of operation. **Bulk** is shown in this illustration.
- **In** displays the present PV array operating voltage and the current being harvested from the array.
- **VOC** displays the open-circuit voltage available from the PV.
- **Out** displays the present battery voltage and the current being delivered from the present charge controller to charge the battery bank. To the right, this line displays the number of kilowatt-hours and amp-hours accumulated that day.
- **Operating** displays the total hours the charger has operated that day in any stage.
- **Float** displays the amount of time the controller has been in the Float stage.
- **Absorb** displays the amount of time the controller has been in the Absorbing stage. The maximum duration is the Absorb time setting. (See pages 32, 42, and 67.)
- **Maximum** displays the maximum amperage and wattage harvested from the PV array that day, and the time both were recorded.
- The lower right corner shows the current status of the charge controller’s Auxiliary (**AUX**) output. (See page 45.)

Figure 27 Charge Controller Soft Key Screens

NOTE: If the FLEXmax 100 shuts down due to a fault condition, the system display will display the status as **Silent**. The **Error** screen (see page 38) will show the cause if it is one of the defined errors on that screen. The system display will show an Event in the appropriate menu. See the system display literature for more information.

See page 55 for additional information on troubleshooting **Error** conditions and faults.

Stats Screen

From the **Charge Controller** screen, the **<Next>** soft key proceeds to the **Charge Controller Stats** screen. This screen shows data accumulated since the system went online or since the last reset.

Screen Items:

The **Maximum** statistics are not incremental. They are updated only if a higher value is measured.

- **VOC** displays the highest measured V_{oc} . (See the **VOC** reading on page 36 for the present V_{oc} .)
- **Battery** displays the highest measured battery voltage. (See the **Out** reading on page 36 for the current battery voltage.)
- **Wattage** displays the highest measured wattage harvested from the PV. (See the **Out** reading on page 36 for the present wattage. See **Maximum** on page 36 for the highest wattage that day.)

The items under **Total** are incremental. These items are updated daily with higher totals.

- **kWh** displays a historical accumulation of the kilowatt-hours harvested by the controller. (See the **Out** reading on page 36 for the daily accumulation.)
- **kAh** displays a historical accumulation of the kiloamp-hours used to charge the batteries. (See the **Out** reading on page 36 for the daily amp-hour accumulation.)

Soft Keys:

<Next> proceeds to the **Error**, **Datalog**, and **Temps** screens (see pages 38 and 39).

<Reset> proceeds to the **Reset** screens for the items under **Maximum** and **Total**. (See Figure 29.)

<Back> returns to the previous screen.

<Port> cycles through each device connected to the network.

Figure 28 Stats Screen

Screen Items:

The **Reset** screens allow the items in the **Stats** screen to be reset to zero (using the **<Yes>** soft key). The items under **Maximum** and **Total** can be reset independently. Until then, they will continue to register higher numbers or greater accumulations.

Soft Keys:

- **<Maximums>** proceeds to the **Reset** screen for the **Maximum** statistics (see Figure 28).
- **<Totals>** proceeds to the **Reset** screen for the **Total** statistics (see Figure 28.)
- **<Back>** returns to the previous screen.
- **<Port>** cycles through each device connected to the network.
- **<No>** returns to the previous screen without resetting.
- **<Yes>** proceeds to a confirmation screen after resetting the item (see the example to the right).
- **<Continue>** returns to the **Charge Controller Stats** screen.

Figure 29 Stats Reset Screens

DataLog Screen

From the **Charge Controller Error** screen, the **<DataLog>** soft key proceeds to the **Charge Controller DataLog** screen. This screen shows accumulated daily amp-hour and watt-hour statistics, as well as maximum current, wattage, and maximum and minimum voltage figures. These maintain a continuous daily log, up to 128 days, which can be recalled. One day can be displayed at a time.



IMPORTANT:

If two or more charge controllers are used in the same system and are started or cleared on different days, their numeric dates will not be the same. This can lead to some misunderstandings when looking back and comparing data between the two or more units. A user looking back at day 12 on both units would find very different results.

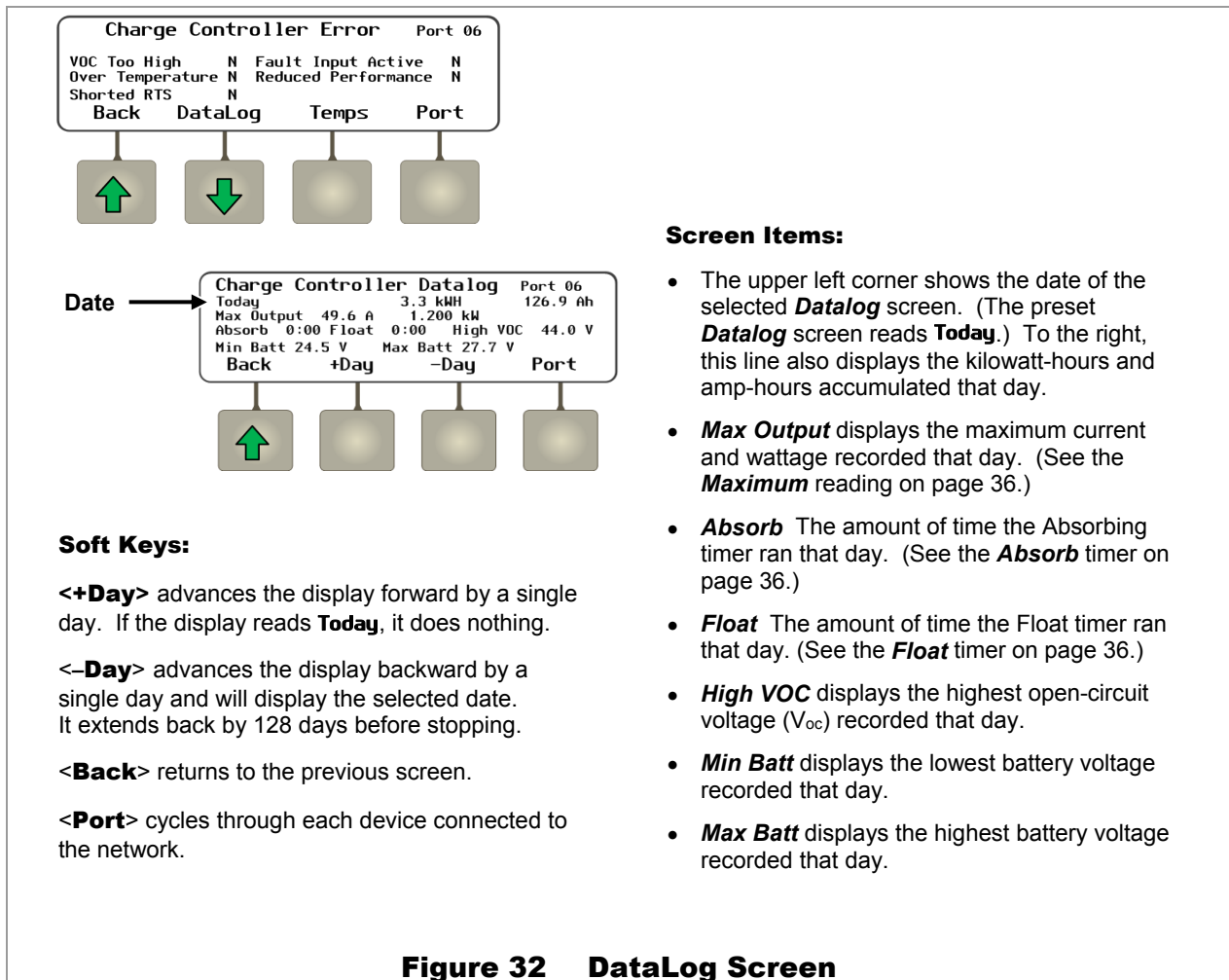
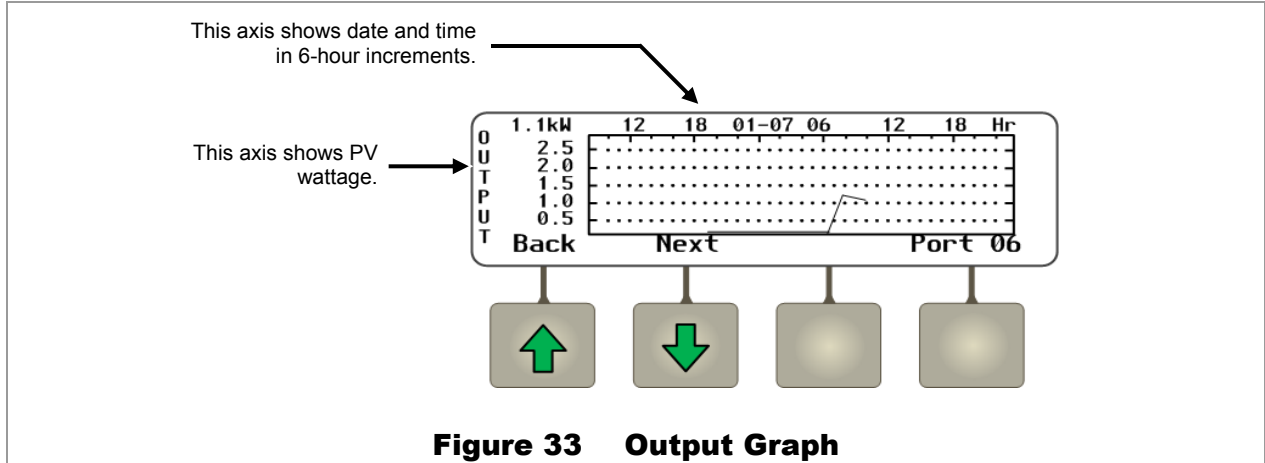


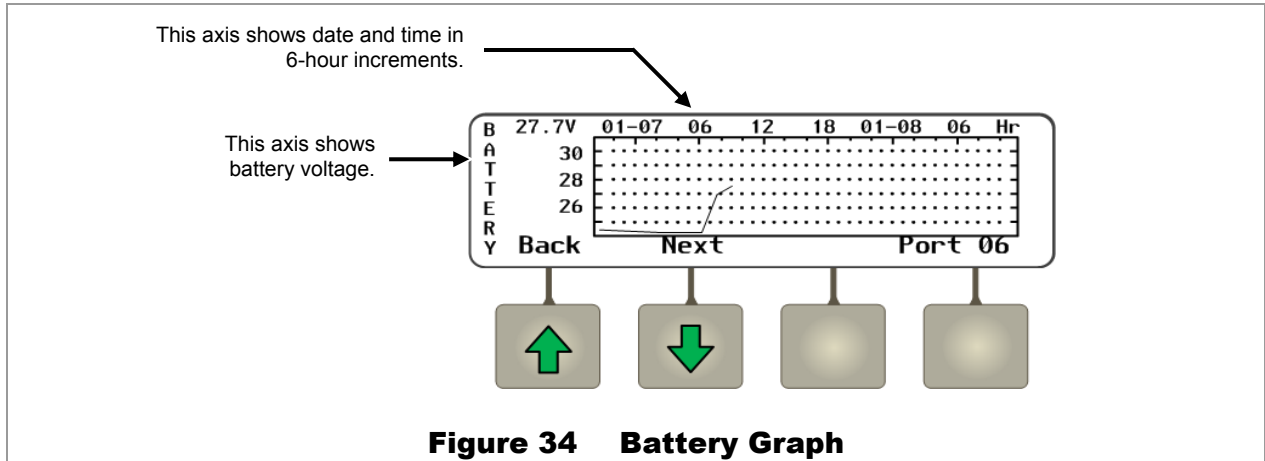
Figure 32 DataLog Screen

Graph Screens

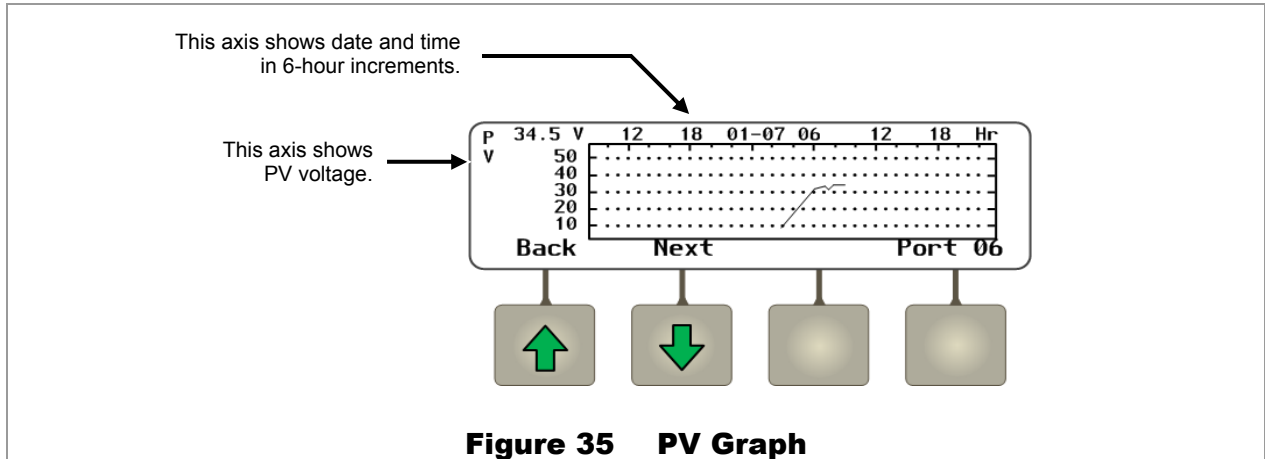
The **<Graph>** soft key brings up the following screens which plot various types of data over time. The first screen shows changes in PV wattage over time.



The **<Next>** soft key brings up a screen showing changes in battery voltage over time.



The **<Next>** soft key brings up a screen showing changes in PV voltage over time.



Continuing to press the **<Next>** soft key will proceed through the same graphs again from the beginning.



Programming the FLEXmax 100

Menu Structure in the MATE3s

Figure 36 shows the menu structure for adjusting the controller settings in a MATE3s system display.

The **Main Menu** shown below is accessed with the **LOCK** button and a password. Use the system display control wheel to move up and down between menus (or options within a menu). Use the center button on the control wheel to make a selection. (See the system display literature for more information.)

Some menus may not be accessible if the user access levels are restricted.

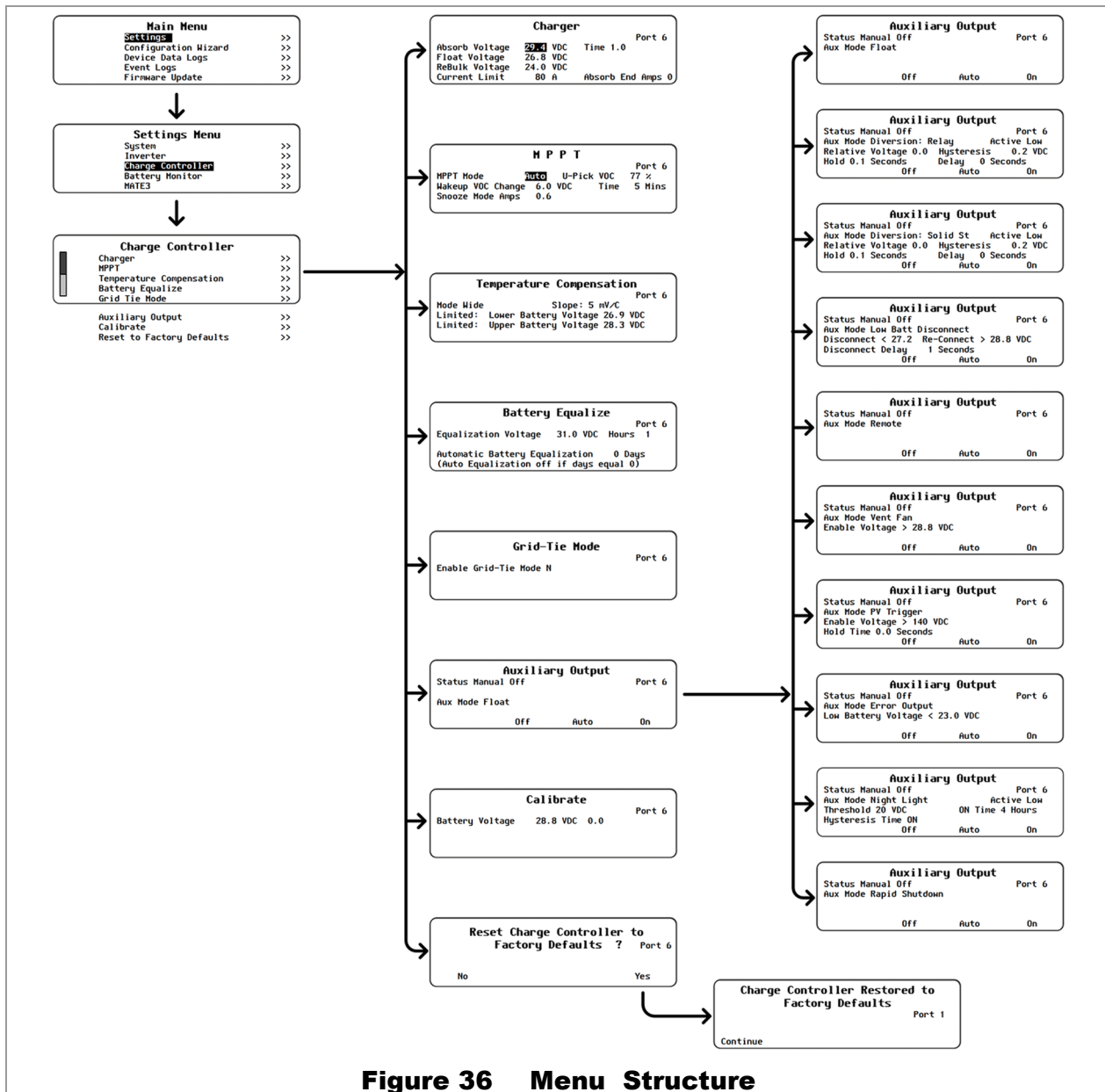


Figure 36 Menu Structure

Charge Controller Settings

Charge Controller menu options include the following:

Charger ----->	See below.
MPPT ----->	See page 43
Temperature Compensation ----->	See page 43.
Battery Equalize ----->	See page 44.
Grid-Tie Mode ----->	See page 44.
Auxiliary Output ----->	See page 45.
Calibrate ----->	See page 50.
Reset Charge Controller to Factory Defaults ----->	See page 50.

Charger



IMPORTANT:

- ❖ Battery charger settings need to be correct for a given battery type. Always follow battery manufacturer recommendations. Making incorrect settings, or leaving them at factory default settings, may cause the batteries to be undercharged or overcharged.
- ❖ An appropriate circuit breaker, or overcurrent device, must be used between the battery and the charge controller.
- ❖ If a battery remote temperature sensor (RTS) is used, set the **Absorb** and **Float** setting voltage based on a 25°C / 77°F setting.

The charge controller uses a “three-stage” battery charging cycle which utilizes multiple settings. This menu controls the voltages and timers for the battery charger. See page 67 for an explanation of the three-stage cycle and a description of individual stages. See page 31 to see what indicators and messages appear at each stage.

Charger			Port 6
Absorb Voltage	29.4 VDC	Time	1.0
Float Voltage	26.8 VDC		
ReBulk Voltage	24.0 VDC		
Current Limit	80 A	Absorb End Amps	0

Set Points:

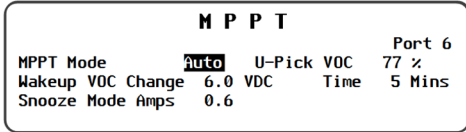
- **Absorb Voltage** – Target voltage for bulk stage. Utilizes constant-current charging.
- **(Absorb) Time** – Amount of time held at Absorb voltage. Utilizes constant-voltage charging.
- **Float Voltage** – Final stage after completion of charge. Utilizes constant-voltage charging.
- **Rebulk Voltage** – Low voltage trigger for new charge.
- **Current Limit** – Maximum DC amps from that controller.
- **Absorb End Amps** – Low current that indicates completed charging. It triggers Float stage regardless of Absorb time.

Figure 37 Charger

- **Absorb Time** is adjustable from 0 to 24 hours (consult the battery manufacturer’s recommendations).
- When the **Absorb Time** is reached, the charge controller goes into Float stage and the system display will show **Float**. When the battery voltage drops below the **Float Voltage** set point, the charge controller will return to MPP operation to draw more PV energy to maintain this set point.

MPPT

The charge controller uses a maximum power point tracking (MPPT) algorithm which manipulates the output of the PV array to harvest maximum wattage. Although this function is automatic, this menu allows the user to adjust many of its parameters for special applications. See page 66.



Set Points:

- **MPPT Mode** – Selects between **Auto** (which allows automatic MPPT) and **U-Pick** (which limits the maximum power point tracking to a specific percentage of array voltage).
- **U-Pick VOC%** – The percentage of open-circuit voltage (V_{oc}) used as the MPP tracking limit in **U-Pick** mode.
- **Wakeup VOC Change VDC** – The change in V_{oc} which will bring the controller out of “Sleep” or “Snooze” operation regardless of the **Time** setting. (See page 34.) The controller will begin locating the power point (“sweeping”). The change in V_{oc} is the indicator that power may be available.
- (Wakeup VOC Change) **Time** – The timer setting to leave “Sleep” or “Snooze” operation regardless of **Change VDC**. The controller will enter MPPT. (It may re-enter “Snooze” and restart the timer if no power is available).
- **Snooze Mode Amps** – The output current limit below which the controller enters “Snooze” due to inactivity.

Figure 38 MPPT

The **MPPT Modes** perform the following functions:

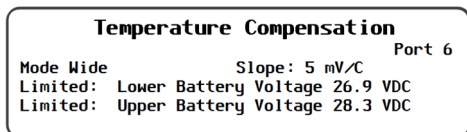
- **Auto Track** (default) automatically measures the PV upon wakeup and then tracks the MPP. (See page 66.)
- **U-Pick** allows the user to manually adjust the MPP tracking limit as a percentage of the array’s V_{oc} .

The **Wakeup VOC Change** settings (**VDC** and **Time**) adjust the V_{oc} conditions that cause the charge controller to wake up during “Sleep” or “Snooze” operation. (See Table 4 on page 34.) Both settings may help adjust for varying conditions. Since environmental conditions impact the open-circuit voltage of an array, the **Wakeup VOC Change VDC** can be based on the last measured V_{oc} value.

Before changing these values, monitor the system for a week or so using the factory defaults and then gradually adjust the set points. If the set points are set too high, the charge controller might not wake up soon enough or often enough, which means a loss of power production.

Temperature Compensation

The **Temperature Compensation** screen allows the user to control the Absorbing and Float voltage limits during charging when using a Remote Temperature Sensor (RTS). The RTS adjusts charging voltage depending on battery temperature. See page 68 for an explanation of compensation.



Set Points:

- **Mode** – Selects between **Limited** (which uses the upper and lower voltage settings below) and **Wide** (which uses the entire range of compensation).
- **Slope** – The amount of temperature compensation. This is measured in millivolts per degree C per battery cell.
- **Limited: Lower Battery Voltage** – The lowest range for temperature compensation in **Limited** mode.
- **Limited: Upper Battery Voltage** – The highest range for temperature compensation in **Limited** mode.

Figure 39 Temperature Compensation

NOTE: If the *Slope* setting is adjusted to any specialized value other than 5 mV, the system display will communicate this value to other networked OutBack devices. The other devices will use the same value. This system-wide compensation only works if there is a single RTS on the system and it is connected to the FLEXmax 100.

In all cases, the batteries should be monitored to ensure they are being charged according to the battery manufacturer's recommendations.

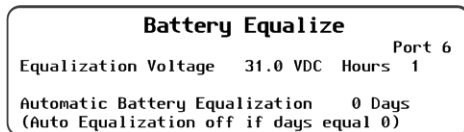
Battery Equalize



CAUTION: Battery Damage

- ❖ Do not equalize any sealed battery types (VRLA, AGM, Gel, or other) unless approved by the manufacturer. Some batteries may suffer severe damage from equalization.
- ❖ Contact the battery manufacturer for recommendations on equalization voltage, duration, schedule, and/or advisability. Always follow manufacturer recommendations for equalization.

Equalization is a controlled overcharge that is part of regular battery maintenance. See pages 33 and 68 for an explanation of equalization. The **Battery Equalize** screen allows the user to control the settings for the equalization process.



Set Points:

- **Equalization Voltage** – Target voltage for equalization.
- **(Equalization) Hours** – Amount of time held at Equalization voltage.
- **Automatic Battery Equalization** – The number of days between equalization cycles.

Figure 40 Battery Equalize

Equalization can be triggered manually with the main button. (See pages 33 and 68.) Equalization can also be triggered automatically on a schedule. The **Days** setting controls this schedule, setting a delay of the appropriate number of days between the end of one cycle and the beginning of the next. If this item is set to zero, the controller will not perform automatic equalization.

Grid-Tie Mode

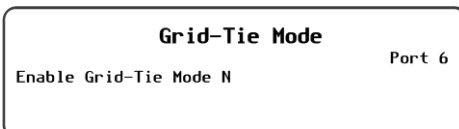


IMPORTANT:

- ❖ This mode requires an OutBack grid-interactive inverter (also known as grid-tie enabled) with its selling mode enabled. Not all inverters are grid-interactive. If the system is connected to an inverter that is not grid-interactive or not enabled, **Grid-Tie** mode will not function.
- ❖ This mode requires both the inverter and the charge controller to be connected to the HUB for communication. It also requires a MATE3s system display. If an OutBack grid-interactive inverter is present but these devices are not on the HUB, **Grid-Tie** mode will not function.

Grid-Tie mode allows the FLEXmax 100 to work more effectively with any grid-interactive inverter installed on the HUB. This mode automatically raises the controller's Float voltage to equal its Absorption voltage. Since the inverter sells power to maintain its own Float, Absorption, or Sell settings (all of which should be lower than the FLEXmax), this mode makes maximum power available for the system to sell.

See page 71 for more information on this mode.



Set Points:

- Two options are available in this menu; **N** and **Y**:
 - ~ **N** (No) disables Grid-Tie Mode
 - ~ **Y** (Yes) enables Grid-Tie Mode

Figure 41 Grid-Tie Mode

Auxiliary Output

The **Aux** (Auxiliary) is a secondary control circuit — essentially, a small power supply that provides a 12 Vdc output current (up to 250 milliamps or 3 watts) to an isolated load. It can be **ON** with 12 Vdc available at the output, or **OFF** with 0 Vdc at the output. It can also be set to **AUTO**. In this setting, the **AUX** output turns on or off according to specific criteria such as high or low voltage. In some cases, such as the **PV Trigger**, **Night Light**, or **Diversion: Relay** applications, the polarity of the output can be reversed so that the behavior is reversed. These selections use the **AUX POLARITY** setting (**HIGH** or **LOW**).

The **Aux** output can control devices such as cooling fans, vent fans, load diversion, fault alarms, and automatic generator control. See page 20 for examples of applications.

- Only one **AUX MODE** can be selected or operate at a time (even if other modes have criteria preset).
- See Figure 43, page 49, for an auxiliary setup wiring diagram example.

NOTE: **Diversion: Relay** and **Diversion: Solid St** can be used for AC coupling applications.

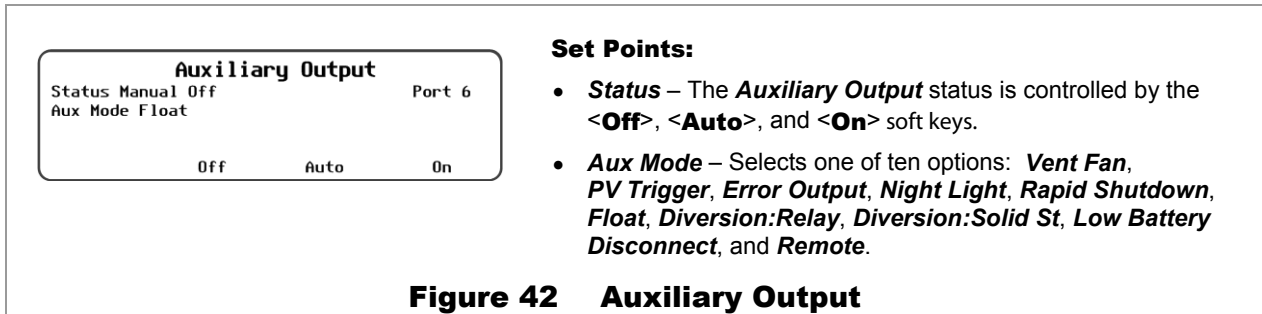


Figure 42 Auxiliary Output

Auxiliary Mode Screens

The ten options appear in the following order when the wheel is drawn clockwise. The **Vent Fan** option appears first if the charge controller is set at factory default values; otherwise, it will tend to display the last option selected.

Table 6 AUX Mode Functions

Mode Name	Function/Purpose	Set Points	AUX Polarity
Vent Fan	<p>Function: When the Enable Voltage set point is exceeded, the Aux output will activate for at least 15 seconds. If the set point continues to be exceeded, the output will remain active until the voltage falls below the set point. Once the voltage decreases below the set point, the Aux output will remain active for another 15 seconds. It will then deactivate.</p> <p>Purpose: This mode is intended to operate a vent fan to ventilate gas from a battery enclosure.</p>	<ul style="list-style-type: none"> • Enable Voltage 	Not Available

Table 6 AUX Mode Functions


Mode Name	Function/Purpose	Set Points	AUX Polarity
<p>PV Trigger</p>	<div data-bbox="396 317 875 447" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6 Aux Mode PV Trigger Active High Enable Voltage > 140 VDC Hold Time 0.0 Seconds Off Auto On</p> </div> <p>Function:</p> <p>When the Enable Voltage set point is exceeded, the Aux output will activate.</p> <p>Once the voltage decreases below the set point, the output will remain active for the duration of the Hold Time set by the user.</p> <p>Purpose:</p> <p>This mode operates an alarm or a PV cutoff relay when PV voltage exceeds a safe value.</p>	<ul style="list-style-type: none"> • Enable Voltage • Hold Time 	<p>Active High: Activates when the voltage exceeds the set point.</p> <p>Active Low: Activates when the voltage drops below the set point; deactivates when the voltage exceeds the set point.</p>
<p> CAUTION: Hazard to Equipment</p> <p>Do not exceed 300 Vdc or the FLEXmax 100 could be damaged.</p>			
<p>Error Output</p>	<div data-bbox="396 806 875 936" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6 Aux Mode Error Output Low Battery Voltage < 23.0 VDC Off Auto On</p> </div> <p>Function:</p> <p>This mode responds to two emergency conditions: low battery or failure to charge. Low battery is defined by Low Battery Voltage. Failure to charge means the PV has not exceeded the battery voltage by 3 Vdc or more for 26 consecutive hours. Either case may mean an array problem.</p> <p>This mode is Active Low only. The Aux output is normally active. When either condition is met, the Aux will deactivate.</p> <p>Purpose:</p> <p>This mode is useful for monitoring remote sites. It indicates when the controller has not charged the batteries for 26 hours or more or if the voltage remains too low for other reasons.</p> <p>Deactivation is intended to operate a remote alarm. It can send a signal through a modem to alert a computer of the problem.</p>	<ul style="list-style-type: none"> • Low Battery Voltage 	<p>Active Low only. Deactivates when the voltage drops below the set point for 10 minutes.</p>
<p>Night Light</p>	<div data-bbox="396 1495 875 1625" style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6 Aux Mode Night Light Active Low Threshold 20 VDC ON Time 4 Hours Hysteresis Time ON OFF 1 Minutes Off Auto On</p> </div> <p>Function:</p> <p>When the PV voltage drops below the Threshold voltage set point for the Hysteresis Time, the Aux output changes states and remains in that state for the ON Time setting.</p> <p>Purpose:</p> <p>This mode is intended to illuminate a small (user-provided) light for as long as the controller remains in Sleep mode or for the ON Time setting.</p>	<ul style="list-style-type: none"> • Threshold voltage • ON Time • Hysteresis Time 	<p>Active High: Activates for a set time when the voltage drops below the set point for a set amount of time.</p> <p>Active Low: Activates for a set time when the voltage exceeds the set point for a set amount of time. Deactivates when the voltage drops below the set point.</p>

Table 6 AUX Mode Functions

Mode Name	Function/Purpose	Set Points	AUX Polarity
<p>Rapid Shutdown</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6 Aux Mode Rapid Shutdown</p> <p style="text-align: center;">Off Auto On</p> </div> <p>Function: The Aux remains deactivated as long as the Rapid Shutdown terminals remain closed (see pages 19 and 24). When the controller senses an open circuit on these terminals and the PV voltage is less than 20 Vdc, the Aux will activate.</p> <p>Purpose: This mode is intended to activate a light or indicator that announces a successful Rapid Shutdown.</p>	<p>None</p>	<p>Not Available</p>
<p>Float</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6 Aux Mode Float</p> <p style="text-align: center;">Off Auto On</p> </div> <p>Function: When the FLEXmax 100 is in the Float stage, the output activates.</p> <p>Purpose: This mode is intended to operate a device such as a “battery full” indicator when the FLEXmax 100 is in the Float stage of battery charging.</p>	<p>None</p>	<p>Not Available</p>
<p>Diversion: Relay</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6 Aux Mode Diversion: Relay Active Low Relative Voltage 0.0 Hysteresis 0.2 VDC Hold 0.1 Seconds Delay 0 Seconds</p> <p style="text-align: center;">Off Auto On</p> </div> <p>Function: In Diversion mode, the Aux output changes state depending on the charger’s present stage of operation. The voltage must exceed the charger setting (Absorb, Float, or EQ) by the value of the Relative voltage. This must last for the Delay time for the Aux to respond. The Aux returns to its previous state when the voltage drops below the Relative setting by an amount equal to Hysteresis. This must last for the Hold time for the Aux to respond. For a wiring diagram illustrating how to connect this function, see Figure 43 on page 49.</p> <p>Purpose: This mode is intended to divert power from the batteries to prevent overcharging by operating a diversion load at the appropriate time. The Aux output operates a mechanical relay that controls the diversion load. Often used with wind or hydroelectric sources.</p>	<ul style="list-style-type: none"> • Relative voltage • Hold time • Delay time • Hysteresis voltage 	<p>Active High: Activates when battery voltage exceeds the set point. Usually controls an auxiliary load to divert power away from the batteries when voltage is too high.</p> <p>Active Low: Activates when battery voltage drops below the set point; deactivates when the voltage exceeds the set point.</p>

Table 6 AUX Mode Functions

Mode Name	Function/Purpose	Set Points	AUX Polarity
<p>Diversion: Solid St</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6</p> <p>Aux Mode Diversion: Solid St</p> <p>Relative Voltage 0.0 Hysteresis 0.2 VDC</p> <p>Hold 0.1 Seconds Delay 0 Seconds</p> <p style="text-align: center;">Off Auto On</p> </div> <p>Function:</p> <p>When the battery voltage increases, the Aux output goes into pulse-width modulation at a rate of 200 Hz. The response is relative to the charger's present stage of operation. The voltage must exceed the charger setting (Absorb, Float, or EQ) by the value of the Relative voltage. This must last for the Delay time for the Aux to respond.</p> <p>The Aux returns to its previous state when the voltage drops below the Relative setting by an amount equal to the Hysteresis voltage. This must last for the Hold time for the Aux to respond.</p> <p>For a wiring diagram illustrating how to connect this function, see Figure 43 on page 49.</p> <p>Purpose:</p> <p>This mode is intended to divert power from the batteries to prevent overcharging by operating a diversion load at the appropriate PWM level. The Aux output operates a solid-state relay for fast and precise control of the diversion load. Often used with wind or hydroelectric sources.</p>	<ul style="list-style-type: none"> • Relative voltage • Hold time • Delay time • Hysteresis voltage 	<p>Not Available</p>
<p>Low Battery Disconnect</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6</p> <p>Aux Mode Low Batt Disconnect</p> <p>Disconnect < 27.2 Re-Connect > 28.8 VDC</p> <p>Disconnect Delay 1 Seconds</p> <p style="text-align: center;">Off Auto On</p> </div> <p>Function:</p> <p>When the battery voltage falls below the Disconnect voltage for the Disconnect Delay time, the Aux output activates. When the battery voltage rises above the Re-Connect voltage, the Aux deactivates.</p> <p>Purpose:</p> <p>This mode is intended to turn off "extra" or noncritical loads when the batteries are low. This will reduce usage and save battery capacity.</p> <p>These loads are usually separated from the main battery loads. They are switched off with a relay which is controlled by the Aux output. Loads not controlled this way may continue using the batteries.</p>	<ul style="list-style-type: none"> • Disconnect • Re-Connect • Disconnect Delay 	<p>Not Available</p>
<p>Remote</p>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px;"> <p style="text-align: center;">Auxiliary Output</p> <p>Status Manual Off Port 6</p> <p>Aux Mode Remote</p> <p style="text-align: center;">Off Auto On</p> </div> <p>Function:</p> <p>An OutBack system display can send external commands to control the Aux output.</p> <p>Purpose:</p> <p>This mode is intended to allow functions such as AGS to control the Aux output. See the system display literature for information on AGS.</p>	<p>None</p>	<p>Not Available</p> <div style="border: 1px solid black; padding: 5px; margin-top: 10px;"> <p> IMPORTANT:</p> <p>The Remote option allows the system display to use the Aux output for Advanced Generator Start (AGS). AGS is intended for systems with a HUB, inverter, and FLEXmax 100. If the system display connects only to a FLEXmax 100, AGS will only work with DC generator programming. The other AGS functions will not work properly.</p> </div>

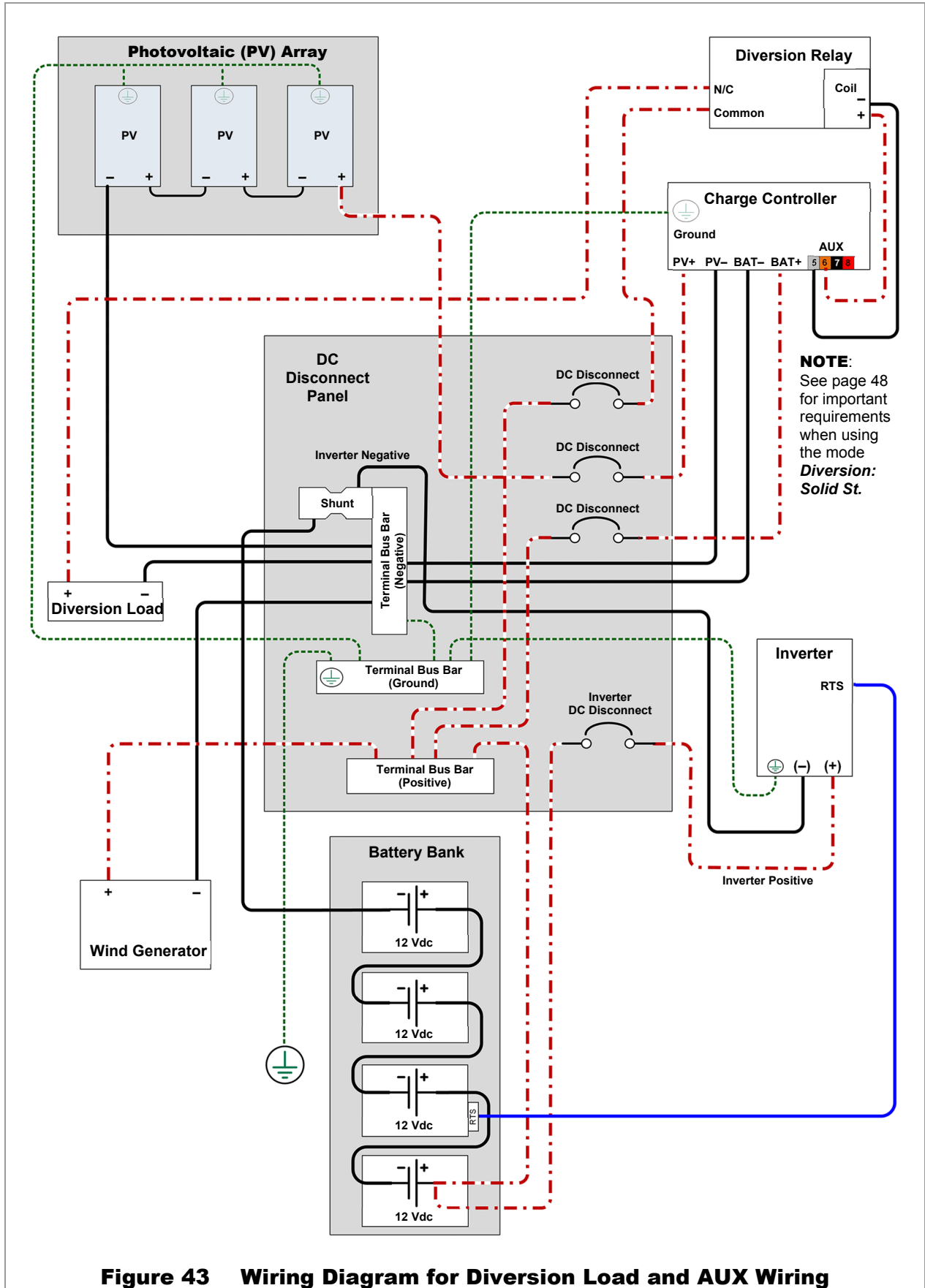


Figure 43 Wiring Diagram for Diversion Load and AUX Wiring

Calibrate

The Calibrate menu allows adjustment of the controller’s battery voltmeter. If a particular controller’s readings do not match those of another device or a hand-held meter, the calibration feature may improve consistency.

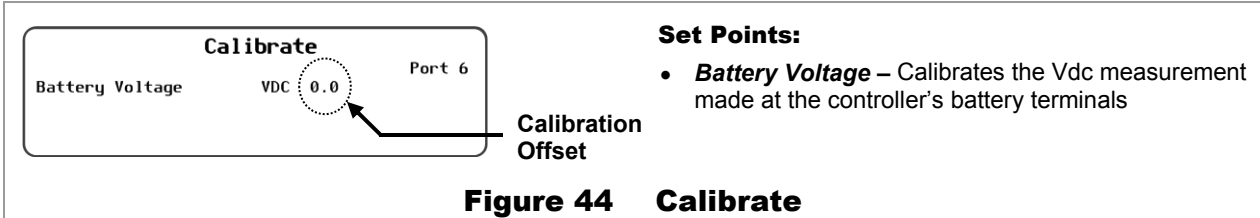


Figure 44 Calibrate

NOTE: Calibration does not change the actual voltage of the charge controller, only the voltage reading.

Also, measurements in places other than the charge controller’s terminals may differ regardless of calibration. For example, it is possible to get a different reading at the charge controller’s DC terminals than on the batteries. Connection problems, corrosion, and the effects of induction and resistance may all result in voltage differences. If this occurs, it is an issue with the system, not the charge controller. Calibration cannot correct for it.

Also note that this function does not affect voltages shown by the system display from other sources such as the FLEXnet DC Battery Monitor or an inverter. It also does not affect voltages displayed using the FLEXmax 100 Battery Sense terminals (see page 21). If any of these readings are shown on the system display, adjusting the **Calibrate** screen will have no effect.

Reset Charge Controller to Factory Defaults

This menu allows the user to erase all settings from the selected charge controller and start over with the values programmed at the factory. These values are listed on page 62. This procedure is recommended any time the controller is relocated or the system is substantially revised.

This procedure is a requirement for resetting the nominal battery voltage of the system (see page 26).

To access the *Reset to Factory Defaults* menu:

1. Access the main menu as shown on page 41.
2. Select the **Settings** screen. (This option may be highlighted by default.)
3. Select **Charge Controller** in the device **Settings** menu.
4. Select the **Reset to Factory Defaults** screen.
5. Use the soft keys to select **No** or **Yes**.
 - If **<No>** is selected, the screen returns to the **Charge Controller** menu. No changes will be made to any settings.
 - If **<Yes>** is selected, the controller’s settings will immediately change to the original factory values. The screen will display the message **Charge Controller Restored to Factory Defaults**. A **<Continue>** soft key will appear. Pressing this key will return the screen to **Charge Controller**.
6. After resetting the charge controller to factory default parameters, turn all power to the controller (PV and battery) off and then on again.

Press **<Continue>** to return to the **Charge Controller** menu (if the MATE3s is still active).

Figure 45 Restoring the Charge Controller to Factory Default Settings

Firmware Revision

To access the FLEXmax 100 firmware revision:

1. Access the *Main Menu* as shown on page 41.
2. Select the *Settings* menu. (This option may be highlighted by default.)
3. Select *System* in the device *Settings* menu.
4. Select the *Firmware Versions* menu.
5. The current firmware revision of the FLEXmax 100 will be displayed along with that of the system display and other devices.

See page 53 for instructions on updating the controller's firmware revision.

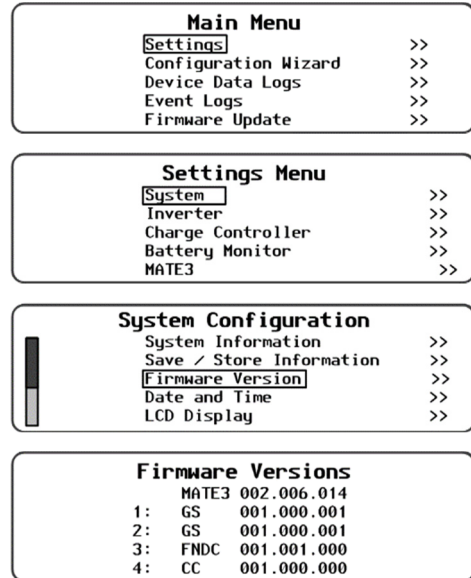


Figure 46 Reading the Firmware Revision

Device Data Logs

Users of a MATE3-class system display can create Device Data Logs for the FLEXmax 100 charge controller. The Data Logs can then be uploaded and saved to an SD card.

Saving Data Logs for the FLEXmax 100

To create a data log for the FLEXmax 100:

1. Access the *Main Menu* as shown on page 41.
2. Select the *Device Data Logs* menu.
3. Select *FLEXmax Charge Controller* menu.
4. Select *Upload and Save Data Log* on the *FM Charge Controller Data Log* menu.
5. Select one of the two options.
 - Press **<New>** to give the new data log a unique name. Or
 - Press **<Save>** to save the data log over the name that is highlighted on the list.
6. After saving the data log is complete, press **<Continue>** to return to the *Upload and Save Data Log* screen.

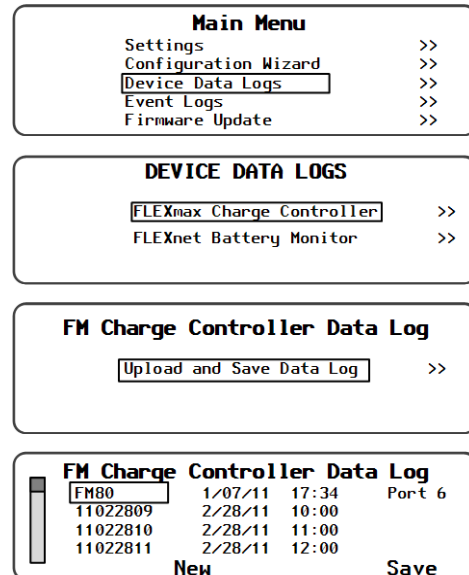
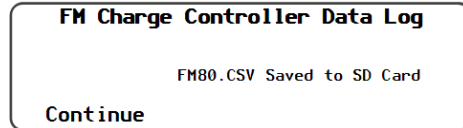
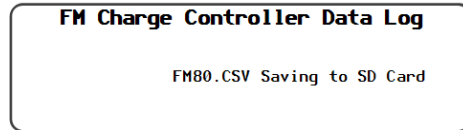


Figure 47 Uploading and Saving a Data Log for the FLEXmax 100

Saving Data Logs (continued)

To save a new data log over the name highlighted on the list:

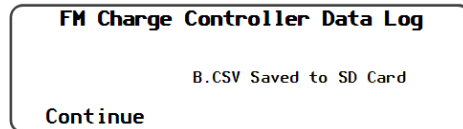
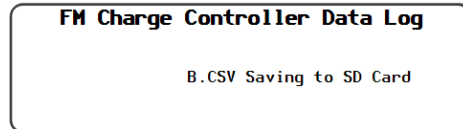
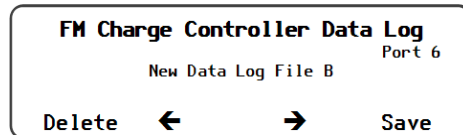
1. Use the control wheel to scroll through the list.
2. When the name to be replaced is highlighted, press **<Save>**.
3. Wait for the message confirming that the profile has been saved to the SD card.
4. Press **<Continue>** to return to the *Upload and Save Data Log* screen.



Returns to the *Upload and Save Data Log* screen.

To create a new name for the data log (up to 8 characters maximum):

1. Use the control wheel to scroll through the available characters.
2. Use **<→>** and **<←>** to move to the next character location.
3. Press **<Delete>** to erase the character that is highlighted.
4. Press **<Save>** to save the new data log on the SD card.
4. Press **<Continue>** to return to the *Upload and Save Data Log* screen.



Returns to the *Upload and Save Data Log* screen.

Figure 48 Uploading and Saving a Data Log (continued)

Data Log File Format

Information generated by this function will be saved on the SD card in a generic **.csv** file format, which can be read by most spreadsheet programs.

Data Logging example:

NOTE: This header line is NOT included in the download.

Date	AH	Kwh	Max Amps	Max Watts	Absorb Time	Float Time	Min Battery V	Max Battery V	MAX V _{oc}
6/13/17	0	0	1.2	29	0:00	0:00	24.1	29.1	122
6/12/17	38	0.9	5.5	143	0:00	0:00	24.1	29	122
6/11/17	32	0.8	5.6	144	0:00	0:00	24.1	28.7	120
6/10/17	9	0.2	3.5	89	0:00	0:00	24.1	28.9	120
6/09/17	31	0.7	6.8	173	0:00	0:00	24.1	28.8	119

Figure 49 Data Log Example for the Charge Controller

Updating the Firmware

The FLEXmax 100 and other OutBack products can be updated to the latest revision by installing the latest firmware. Firmware can be downloaded from the website, www.outbackpower.com, to one of several types of SD memory card (see below). The firmware is available for download on the FLEXmax 100 product page or the Firmware page. Make certain the SD card uses FAT32 format.



IMPORTANT:

Make certain to extract (unzip) the files to the root directory of the SD card. Do not extract to a folder. Do not save the original file directly in its original compressed form. If the files are downloaded in compressed form, they will be unusable.

Using MATE3s

To update the firmware revision with the MATE3s system display, refer to the MATE3s literature. Download and extract the latest firmware revision as noted above. Transfer the files to a standard SD memory card. Instructions for the specific process are provided in the MATE3s literature.

Once the update procedure is started, it will take over ten minutes for the files to be transferred to the FLEXmax 100. While this is occurring the MATE3s will show the percentage completed. The charge controller will show normal LED activity and will continue charging as normal.

At the end of the file transfer the FLEXmax 100 **STATUS** LED indicator will flash green rapidly. It will change to flashing red slowly, then flash red more quickly. See Figure 51 (on the next page) or page 29.

When the update process is complete, all LED indicators will flash in sequence as in a standard power-up routine. The internal fan will run briefly. The MATE3s will return to its home screen.

Without MATE3s

To update the firmware revision directly:

1. Turn off the battery and PV disconnect devices. Ensure the FLEXmax 100 has no power from any source.
2. If present, remove the microSD card from the FLEXmax 100. (See Figure 50.) The card can be ejected by pressing on the exposed end. It should depress slightly and then protrude with a click. Afterward it can be easily removed.

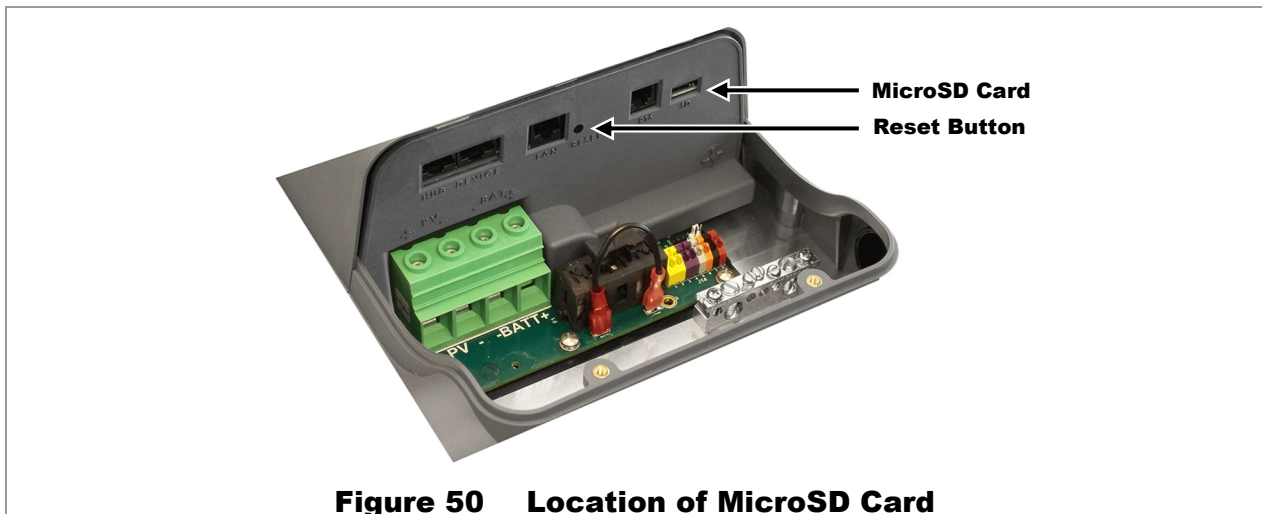


Figure 50 Location of MicroSD Card

Updating Firmware

3. Download the latest firmware revision as noted on page 53. Transfer the files to the microSD card.
4. If the file called **FN100-00.bin** was previously present on the card, delete it and replace it with the downloaded file with that name. This file needs to be in the root directory, not in a separate folder.
5. Before removing the card from the computer it is recommended to eject it using the computer's onscreen **Eject** command (usually titled **Safely Remove Hardware, Eject Media**, etc.).
6. Insert the card back into the FLEXmax 100. Ensure it clicks into position similarly to the way it was previously removed.

NOTE: The following steps require access to the controller and battery disconnect at the same time. Two people may be needed.

7. Press and hold the **RESET** button with a nonconductive narrow tool. (See Figure 50. The button is recessed inside the hole by several millimeters.)
8. While still pressing the **RESET** button, turn the battery disconnect to the **ON** position.
9. Still pressing the **RESET** button, watch the LED indicators on the FLEXmax 100. (See Figure 51.) When the **STATUS** LED indicator flashes green rapidly, the programming process has started. It is safe to release the button.

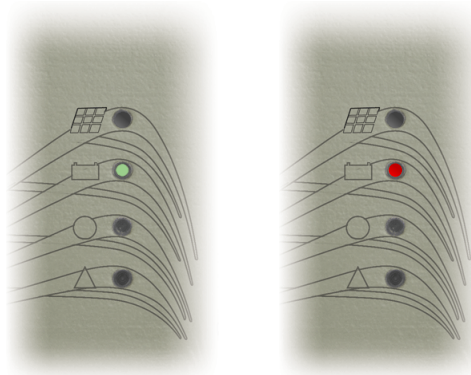


Figure 51 Status Indicator

10. Within a few seconds the **STATUS** indicator will begin flashing red instead of green. After approximately 10 seconds it will flash red more quickly.
11. When the update process is complete, all LED indicators will flash in sequence as in a standard power-up routine. The internal fan will run briefly.

The firmware update process is complete.



Troubleshooting



IMPORTANT:

Check the OutBack customer and user forum at www.outbackpower.com/forum/ for more FLEXmax 100 information.


General Troubleshooting

An OutBack MATE3s system display may be required for certain troubleshooting steps in Table 7.

Table 7 Troubleshooting

Symptom	Remedy
Unit does not power up upon initial connection (no LED indicators or system display operation)	<ul style="list-style-type: none"> Check the battery connection and polarity. Reverse polarity or an improper connection will cause power-up issues. Check the battery circuit breaker or device. Ensure all items are sized appropriately. Check the battery voltage at the FLEXmax 100 terminals. A battery voltage below 15 Vdc may not power up the charge controller. A poor connection may not allow sufficient voltage to reach the charge controller. Rapid shutdown condition. The system display Fault Input Active message will show Y (see page 38). This is not a controller error but a deliberate action. See pages 19, and 24, and 57 for more information. Resetting this condition requires resetting the external rapid shutdown device.
Unit powers up but does not operate. PV voltage is present but drops to a few volts when connected.	Check PV wiring. This will occur if the PV array wiring polarity is reversed. The heatsink may grow warm after a short time due to internal current flow.
Unit not operating; unit had worked normally before	<ul style="list-style-type: none"> This behavior is normal in cases of low light. Unit may be in “Sleep”, “Snooze”, or “Wakeup” modes. Confirm conditions and behavior using Table 4 on page 34. Battery temperature fault. Check temperature (see system display literature). If the RTS reads in excess of 50°C, it indicates a battery too hot to safely operate. Rapid shutdown condition. The system display Fault Input Active message will show Y (see page 38). This is not a controller error but a deliberate action. See pages 19, and 24, and 57 for more information. Resetting this condition requires resetting the external rapid shutdown device.
Unit not operating; red FAULT indicator lit	Ground fault. The detection circuit has sensed an open connection on the GFDI fuse (see page 15). The system display GFDI Fault message will show Y (see page 38). Check the fuse. Make certain it is installed according to the instructions. Inspect the rest of the system for grounding problems or shorted connections.
Charging is not temperature-compensated	<ul style="list-style-type: none"> The FLEXmax 100 is performing equalization (see pages 44 and 68). This function is not temperature-compensated. It is not a controller error but a deliberate action. Remote Temperature Sensor (RTS) damaged. The system display Shorted RTS message will indicate Y. (See page 38.) To test, remove or replace the RTS.

Table 7 Troubleshooting

Symptom	Remedy
Unit not operating; unit had worked normally before; normal light conditions	<ul style="list-style-type: none"> Check the charging stage. Check other controllers (if present). If the batteries are nearly charged, one controller may taper off (in the Absorption or Float stage) while the other(s) complete the charge. High temperature fault. Check controller temperature (see page 38). The FLEXmax 100 will stop functioning at an Output FETs reading of 90°C. The system display Over Temperature error will indicate Y. (See page 38.) High V_{oc} fault. Check PV array voltage. If the open-circuit voltage (V_{oc}) is too high, the controller cannot safely operate. The system display VOC Too High error will indicate Y. (See page 38.) The FLEXmax 100 will automatically restart operation once the V_{oc} decreases to a safe level. <p>Upper limits: 24-volt system = 275 Vdc, 36-volt system = 283 Vdc, 48-volt system = 290 Vdc. See page 66 for more information.</p> <p> CAUTION: Hazard to Equipment Voltages in excess of 300 Vdc are likely to damage the FLEXmax 100. The PV array should be designed to avoid ever reaching these voltages.</p>
Unit not producing expected power	<ul style="list-style-type: none"> Check PV and battery voltages. If they are varying widely, the controller may be in the process of an MPPT sweep. It should settle on a stable power point and produce normally again after a short time. Check PV conditions. Clouds, shading, or dirty modules cause poor performance. Check battery conditions and charging stage. If the batteries are charged (if the controller is in the Absorbing or Float stage), the controller will produce only enough power to regulate the voltage at those set points. Less power is required. Determine the specified short-circuit current of the PV array. The MPP current is related to this number. Use a multimeter to determine if the short-circuit current is in the expected range. Array or wiring problems may restrict the available power. Check the PV array temperature. At high temperatures, the maximum power point voltage may be near or lower than the battery voltage. Check FLEXmax 100 external temperature. The output is derated above ambient temperatures of 25°C (77°F). Also check FLEXmax 100 internal temperature using the system display. See page 38. <p>If a temperature reading is greater than 142°C or less than -40°C, a sensor may have failed. The Reduced Performance error will show Y (see page 38).</p> <p>NOTE: If the temperature is high, check the condition of the heatsink. This may require dismounting the controller. If the heatsink is blocked with mud, organic material, etc., the controller will not receive normal ventilation. Clean it by scraping between the fins with a thin wooden stick. Spraying is not recommended.</p>
Unit in equalization cycle but not achieving expected results	<ul style="list-style-type: none"> Check equalization settings using the system display. (See pages 44 and 68). The default settings are not sufficient for many batteries and may need to be adjusted. The cycle will begin when the Equalization Voltage set point has been reached. A small array or cloudy weather will delay the equalization cycle. Running too many battery loads will also delay the cycle. Loads should be removed or minimized. Check the PV array temperature. At high temperatures, the maximum power point voltage may be near or lower than the battery voltage. This can delay the cycle.
Battery Calibration setting does not respond	The system display will not report this setting if remote battery sensing is connected. To test this function, temporarily disconnect remote battery sensing. (See page 21.)

Troubleshooting Error Messages

Error messages are caused by known faults. These are defined by a list of messages in the **Charge Controller Error** screen of the system display. See page 38. See the system display literature for instructions on navigating to this screen.

Table 8 shows the messages available in the system display. One or more messages will display **Y** to indicate an error. If a message says **N**, it is not the cause of the error.

See Table 7 to troubleshoot symptoms not necessarily represented by error messages.

NOTE: Most errors shown in Table 8 are not accompanied by the red **FAULT** LED indicator. The exception is **GFDI Fault**.

Table 8 Error Messages

Message	Symptom	Problem
VOC Too High	24-volt system $\geq 275 V_{oc}$ 36-volt system $\geq 283 V_{oc}$ 48-volt system $\geq 290 V_{oc}$	If the open-circuit voltage (V_{oc}) is too high, the FLEXmax 100 cannot safely operate. The controller will automatically restart operation once the V_{oc} decreases to a safe level.
Over Temperature	Controller hot to the touch	High temperature fault. Check controller temperature (see page 38). The FLEXmax 100 will stop functioning at an Output FETs reading of 90°C.
Shorted RTS	Charging is not temperature-compensated	Remote Temperature Sensor (RTS) damaged. To test, remove or replace the RTS.
GFDI Fault	Red (FAULT) LED indicator illuminated (see page 30)	Ground fault. The detection circuit has sensed an open connection on the GFDI fuse (see page 15). Check the fuse. Make certain it is installed according to the instructions. Inspect the rest of the system for grounding problems or shorted connections.
Fault Input Active	LED indicator(s) illuminated on rapid shutdown device Red (FAULT) LED indicator (see page 30) will flash twice before this occurs	Rapid shutdown condition. This is not a controller error but a deliberate action. See pages 19 and 24 for more information. Resetting this condition requires resetting the external rapid shutdown device.
Reduced Performance	Temperature reading is greater than 142°C or less than -40°C	Internal temperature sensor failed. If a failure is detected, the controller will operate with a maximum output of 20 Adc.
Over Current Fault	Controller has shut down	This occurs if more than 80 amps flow from the battery to the FLEXmax 100, or if more than 120 amps flow from the controller to the battery. <ul style="list-style-type: none"> To restart the FLEXmax 100, remove all power from the controller and then reconnect the batteries. If the problem recurs, loose or shorted contacts may be present. The PV array may also be oversized.

Troubleshooting Firmware Updates

Certain problems may occur when updating the controller's firmware revision. See page 53.

Table 9 Firmware Update Issues

Symptom	Possible Cause	Possible Remedy
MATE3s displays No SD Card Installed on FM100	MicroSD card not installed or completely seated	Insert microSD card. Make certain it is completely seated. See pages 53 and 54.
No LED indicators illuminate when pressing RESET button while connecting battery	Problem with file on microSD card	<ul style="list-style-type: none"> • Disconnect the battery. Try connecting three or four more times. • If problem persists, remove the card from the slot. Delete all files, reload, and try again.
STATUS (green) LED indicator does not flash rapidly when pressing RESET button while connecting battery		
STATUS LED indicator flashes rapid green, followed by erratic red flash (followed by steady red flash and then power-up sequence)	Previous update attempt was interrupted by power disconnect, loss of communication, or a similar problem	No solution required; current update has succeeded
STATUS LED indicator flashes rapid green, but does not flash slowly within a few seconds	Problem microSD card or with file on microSD card	<ul style="list-style-type: none"> • Disconnect the battery. Try connecting up to six more times. • If problem persists, remove the card from the slot. Delete all files, reload, and try again.
STATUS LED indicator does not flash, but startup LED indicator sequence runs when pressing RESET button while connecting battery	Button not fully pressed when powering up	Ensure button is fully pressed when powering up
	MicroSD card not installed or completely seated	Insert microSD card. Make certain it is completely seated. See pages 53 and 54.
	FN100-00.bin file is not in correct location on microSD card	Ensure file is located in the root directory of the microSD card



Specifications

Table 10 Electrical and Mechanical Specifications

Specification	Value
Maximum Continuous Output Current	100 Adc
Maximum Input Current (short-circuit)	64 Adc
Nominal Battery System Voltage	24, 36, or 48 Vdc (automatically adjusted)
PV Open-Circuit Voltage	300 Vdc (highest open-circuit voltage before equipment damage)
Operating Voltage Range	Low 15 Vdc (lowest battery voltage for functionality)
	High 290 Vdc temperature corrected V_{oc} (operational maximum)
Standby Power Consumption	~2.5 W
Charge Cycle	Three-stage
Minimum Battery Bank Size	100 Ahr
Charging (Output) Range	20 to 68 Vdc
Temperature Compensation	Adjustable from 2 mV/cell/°C to 6 mV/cell/°C
Remote Interface	RJ45 modular connector (CAT 5-style 8-wire twisted-pair cable)
Conduit Openings	Sides, bottom (plugs inserted); 1½" diameter openings for 1" conduit size
Dimensions (H x W x D)	22.0" x 8.8" x 6.0" (47.1 cm x 22.4 cm x 15.2 cm)
Shipping Dimensions (D x W X L)	10.0" x 12.0" x 25.5" (25.4 cm x 30.5 cm x 64.8 cm)
Weight	18.3 lb (8.3 kg)
Shipping Weight	22.0 lb (9.9.kg)

Table 11 Environmental / Safety Specifications

Specification	Value
Operating Temperature Range	Ambient -20°C to 60°C (-13°F to 140°F)
Output Power Temperature Derating	Ambient 25°C to 60°C (77°F to 140°F); controller begins derating at 25°C
Environmental Category	Outdoor
Suitable for Wet Locations	Yes
Ingress Protection Rating	IP54
Relative Humidity Rating	4% to 100% Condensing
Enclosure Type	Type 3R
Maximum Altitude Rating	10,000 ft
Overvoltage Category	PV: OV Cat II
	Batt: OV Cat II

Regulatory Specifications

Listings

This product carries a listing report by ETL. It is listed to the following standards:

- UL1741 — Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources — Issue: 2010/1/28 Ed: 2
- CSA C22.2 — *General Use Power Supplies*, No. 107.1-01 — Issue: 2001/09/01 Ed:3 (R2011)

Directives

This product meets the following directives.

- RoHS: Directive 2011/65/EU — “The restriction of the use of certain substances in electrical and electronic equipment”
- Low Voltage Directive: 2006/95/EC — “On electrical equipment designed for use within certain voltage limits”
- Electromagnetic Compatibility Directive: 2004/108/EC — “On electromagnetic compatibility”

Certifications

This product is certified to the following standards:

- IEC 62109-1:2010 — Safety of Power Converters for use in Photovoltaic Systems (2010)

Compliance

This product complies with the following standards:

- IEC 61000-6-1 (EMC Standard: Immunity for Residential, Commercial, and Light-Industrial Environments)
- IEC 61000-6-3: 2007; also CISPR 22: 2008 Class B; also EN 55022 (EMC Standard: Emissions for Residential, Commercial, and Light-Industrial Environments)
- FCC Part 15.109(G): 2012 Class B



FCC Information to the User

This equipment has been tested and found to comply with the limits for a Class B digital device when powered by a DC source, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and the receiver.
- Consult the dealer or an experienced radio/TV technician for help.

Firmware Revision

This manual applies to FLEXmax 100 charge controllers with a firmware revision of 001.001.000 or higher.

To check the current revision using the system display, see page 51.

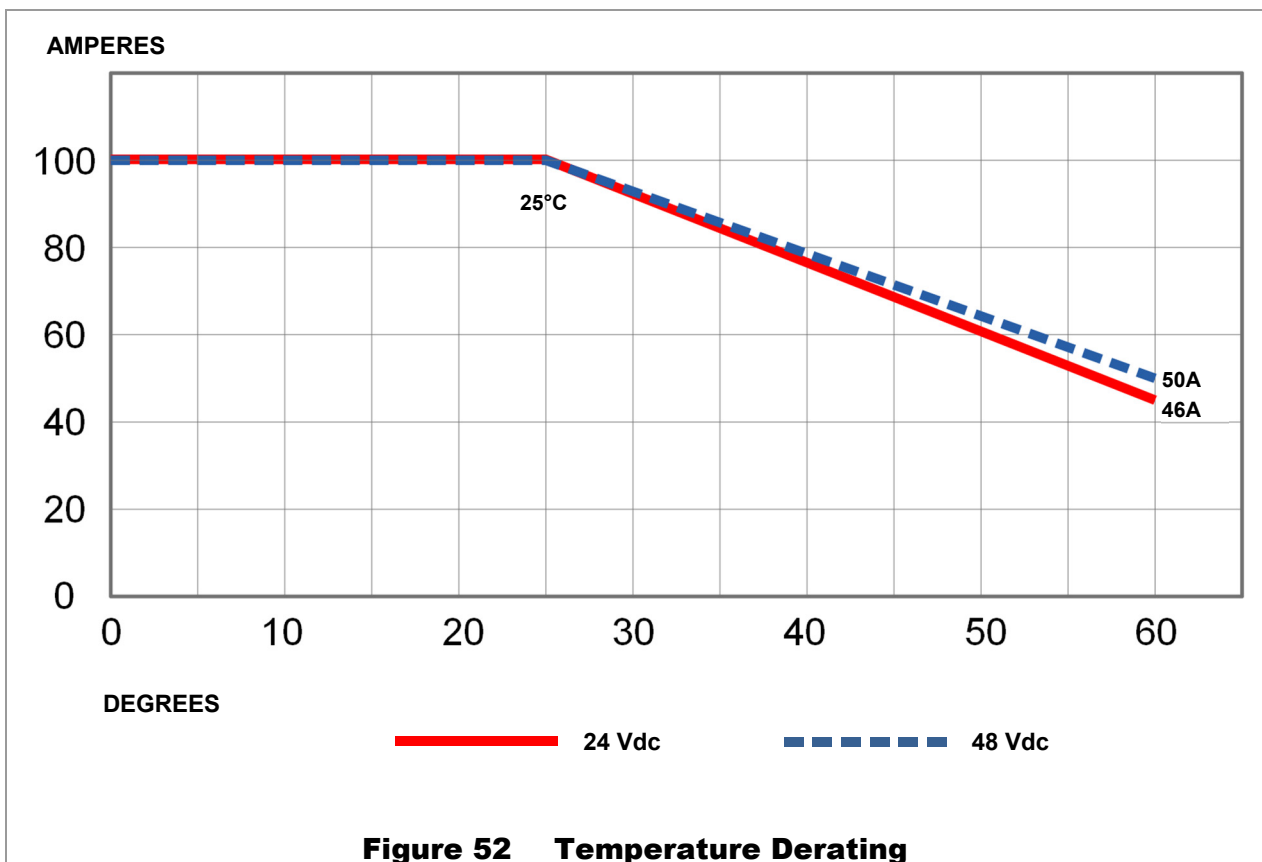
For instructions on updating the firmware revision, see page 53.

Temperature Range and Derating

In standard installations, the FLEXmax 100 can operate at its full 100-amp capacity at ambient temperatures up to 25°C (77°F). Above this temperature, its output is derated as described below.

The values depicted in Figure 52 are examples for a system with a PV input of 220 Vdc. Lower input voltage will improve the controller's thermal performance.

- For a nominal 24-volt battery system:**
 At 60°C (140°F), the output is derated to a maximum of 46 Adc. The controller is not rated for operation above this temperature.
- For a nominal 48-volt battery system:**
 At 60°C (140°F), the output is derated to a maximum of 50 Adc. The controller is not rated for operation above this temperature.



See page 38 for the internal temperature reading which results in temperature derating.

Default Settings and Ranges

The settings in this table are as shown in the system display.

Table 12 FLEXmax Settings

Mode	Menu Item	Setting			
		Value	24-volt	36-volt	48-volt
Charger	Absorb Voltage	Default	28.8 Vdc	43.2 Vdc	57.6 Vdc
		Range	Float setting to 68.0 Vdc		
	(Absorb) Time	Default	01.0 hours		
		Range	00.0 to 24 hours		
	Float	Default	27.6 Vdc	41.4 Vdc	55.2 Vdc
		Range	20.0 Vdc to Absorbing setting		
	Rebulk Voltage	Default	24.0 Vdc	36.0 Vdc	48.0 Vdc
		Range	10.0 Vdc to Float setting		
	Current Limit	Default	100 Adc		
		Range	5 to 100 Adc		
Absorb End Amps	Default	00 Adc			
	Range	00 to 55 Adc			
MPPT	MPPT Mode	Default	<Auto >		
		Range	<Auto> or U-Pick >		
	U-Pick VOC	Default	77% Voc		
		Range	40 to 90% Voc		
	Wakeup VOC Change	Default	3.0 Vdc	4.5 Vdc	6.0 Vdc
		Range	1.5 to 9.5 Vdc		
	(Wakeup VOC) Time	Default	05 minutes		
		Range	05 to 15 minutes		
Snooze Mode Amps	Default	0.6 Adc			
	Range	0.2 to 1.0 Adc			
Temperature Compensation	Mode	Default	<Wide >		
		Range	<Wide> or <Limited>		
	Slope	Default	5 mV		
		Range	2 to 6 mV		
	Lower Battery Voltage	Default	26.4 Vdc	39.6 Vdc	52.8 Vdc
		Range	10 Vdc to Upper Battery Voltage setting		
Upper Battery Voltage	Default	28.2 Vdc	42.3 Vdc	56.4 Vdc	
	Range	Lower Voltage setting to 68.0 Vdc			
Battery Equalize	Equalization Voltage	Default	28.8 Vdc	43.2 Vdc	57.6 Vdc
		Range	Absorb Voltage setting to 68.0 Vdc		
	(Equalization) Hours	Default	01 hours		
		Range	1 to 7 hours		
	Automatic Battery Equalization	Default	0 days		
		Range	0 to 250 days		
Grid-Tie Mode	Enable Grid-Tie Mode	Default	N		
		Range	Y or N		
Auxiliary Output	Vent Fan	Default	<Off>		
		Range	<On, Auto, Off>		
	Enable Voltage	Default	28.8 Vdc	43.2 Vdc	57.6 Vdc
		Range	20.0 to 68.0 Vdc		
	PV Trigger	Default	<Off>		
		Range	<On, Auto, Off>		
	Active	Default	Active High		
		Range	Active High or Active Low		
	Enable Voltage	Default	24.0 Vdc		
		Range	20 to 250 Vdc		
Hold Time	Default	0 Vdc			
	Range	0 to 25 seconds			

Table 12 FLEXmax Settings

Mode	Menu Item	Setting				
		Value	24-volt	36-volt	48-volt	
Auxiliary Output	Error Output	Default	<Off>			
		Range	<On, Auto, Off>			
	Low Battery Voltage	Default	23.0 Vdc	34.5 Vdc	46.0 Vdc	
		Range	20.0 to 68.0 Vdc			
	Night Light	Default	<Off>			
		Range	<On, Auto, Off>			
		Active	Default	Active High		
			Range	Active High or Active Low		
		Threshold	Default	10 Vdc		
			Range	5 to 250 Vdc		
		ON Time	Default	4 hours		
			Range	00 to 23 hours		
	Hysteresis Time	Default	1 minute			
		Range	1 to 255 minutes			
	Rapid Shutdown	Default	<Off>			
		Range	<On, Auto, Off>			
	Float	Default	<Off>			
		Range	<On, Auto, Off>			
	Diversion: Relay	Default	<Off>			
		Range	<On, Auto, Off>			
		Active	Default	Active High		
			Range	Active High or Active Low		
		Relative Voltage	Default	0 Vdc		
			Range	0.0 to 5.0 Vdc		
		Hysteresis	Default	0.2 Vdc		
			Range	0.0 to 12.0 Vdc		
		Hold	Default	0.1 second		
			Range	0.0 to 25 seconds		
	Delay	Default	0.0 seconds			
		Range	0.0 to 24 seconds			
	Diversion: Solid St	Default	<Off>			
		Range	<On, Auto, Off>			
		Relative Voltage	Default	0.0 Vdc		
			Range	0.0 to 5.0 Vdc		
		Hysteresis	Default	0.2 Vdc		
			Range	0.0 to 12.0 Vdc		
		Hold	Default	0.1 second		
			Range	0.0 to 25 seconds		
	Delay	Default	0.0 seconds			
		Range	0.0 to 24 seconds			
	Low Batt Disconnect	Default	<Off>			
		Range	<On, Auto, Off>			
		Disconnect	Default	27.2 Vdc	40.8 Vdc	54.4 Vdc
			Range	20.0 to 68.0 Vdc		
		Reconnect	Default	28.8 Vdc	43.2 Vdc	57.6 Vdc
			Range	20.0 to 68.0 Vdc		
	Disconnect Delay	Default	01 second			
		Range	0 to 250 seconds			
	Remote	Default	<Off>			
		Range	<On, Auto, Off>			



Applications

Array Design

Sizing Guidelines

Below is a list of maximum array wattages for the FLEXmax 100 for various nominal voltage batteries. This should be used for sizing an array. Note that every PV module is different. The specifications for every model should be consulted before designing or assembling a PV array.

Table 13 Maximum Input Wattage Per Charge Controller

Nominal Battery Voltage	Maximum Array Size (Standard Test Conditions)
24 V	3000 W
36 V	4500 W
48 V	6000 W

Maximum-Power Voltage (V_{mp})

Maximum-power voltage (V_{mp}) is the operating voltage for the PV array at which the array generates the most wattage. To perform battery charging, the V_{mp} must always be higher than the battery voltage. When designing the PV array, use the following rule: For optimum charging performance, the V_{mp} should be at least 6 to 10 volts higher than the highest charging voltage for that battery model.



IMPORTANT:

Check the PV array voltage before connecting it to the FLEXmax 100.

Open Circuit Voltage (V_{oc})

Open-circuit voltage (V_{oc}) is the *unloaded* voltage generated by the PV array. The FLEXmax 100 controller can withstand V_{oc} of up to 300 Vdc. However, if the V_{oc} exceeds the following voltages, the controller will suspend operation to protect the system components. (See pages 38 and 57.)

- 24-volt system $\geq 275 V_{oc}$
- 36-volt system $\geq 283 V_{oc}$
- 48-volt system $\geq 290 V_{oc}$



CAUTION: Equipment Damage

Although the FLEXmax 100 shuts down at high DC voltages, this will not prevent the array from generating voltage. Anything higher than 300 Vdc will damage the controller, whether it has shut down or not. The array should be designed so that voltage never exceeds the voltages listed here in order to prevent equipment damage.

Temperature Conditions

PV voltages are specified at room temperature but change inversely with ambient temperature changes. Higher temperatures result in lower V_{oc} and V_{mp} . Lower temperatures result in higher V_{oc} and V_{mp} .

Excessively cold weather can cause the V_{oc} to rise above the array's rated limit. A poorly-sized array can exceed 300 V_{oc} and damage the controller. To avoid exceeding the maximum voltage in very cold temperatures, make certain to calculate the maximum V_{oc} using the module temperature correction factor.

If the specific voltage temperature correction factor is not known for a particular module, allow for ambient temperature correction using the following information:

25° to 10°C (77° to 50°F)	multiply V_{oc} by 1.06
9° to 0°C (49° to 32°F)	multiply V_{oc} by 1.10
-1° to -10°C (31° to 14°F)	multiply V_{oc} by 1.13
-11° to -20°C (13° to -4°F)	multiply V_{oc} by 1.17
-21° to -40°C (-5° to -40°F)	multiply V_{oc} by 1.25

Maximum Power Point Tracking

Maximum Power Point Tracking (MPPT) is the technology used by FLEXmax charge controllers to optimize the harvest of power from PV arrays.

PV modules do not have a defined operating voltage. Their voltage is defined strictly by the load connected to them. With no load (disconnected), a module displays "open-circuit" voltage (V_{oc}), and delivers no current. At full load (shorted), a module has no voltage, although it delivers the maximum "short-circuit" current (I_{sc}). In neither case does it produce usable wattage.

When partially loaded, a PV module delivers partial current and voltage. These numbers can be multiplied to see the available wattage. However, the delivery of wattage is not linear. The current and voltage delivered at a given load will change with the load, along a curve such as that shown in the drawing to the left in Figure 53. This is known as the I-V curve. The wattage is different at every point along the curve. (The I-V curve also varies with module type and manufacturer.) Only one point on the I-V curve represents the delivery of the module's maximum (rated) wattage. This is known as the maximum power point, or MPP. The current at this point, I_{mp} , is the highest that can be drawn while still maintaining the highest voltage, V_{mp} .

The FLEXmax 100 controller places a variable load on the PV array and tracks the result to determine the maximum power point. This process, MPPT, is maintained so that the controller can deliver the maximum PV power regardless of any change in conditions. The drawing to the right in Figure 53 shows the MPP and compares the I-V curve against the available wattage.

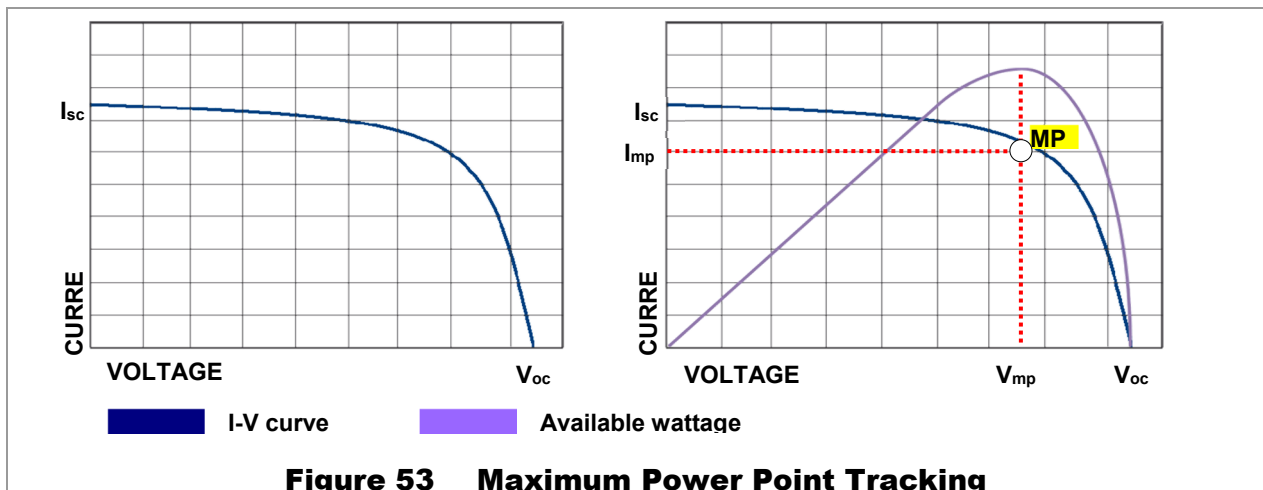
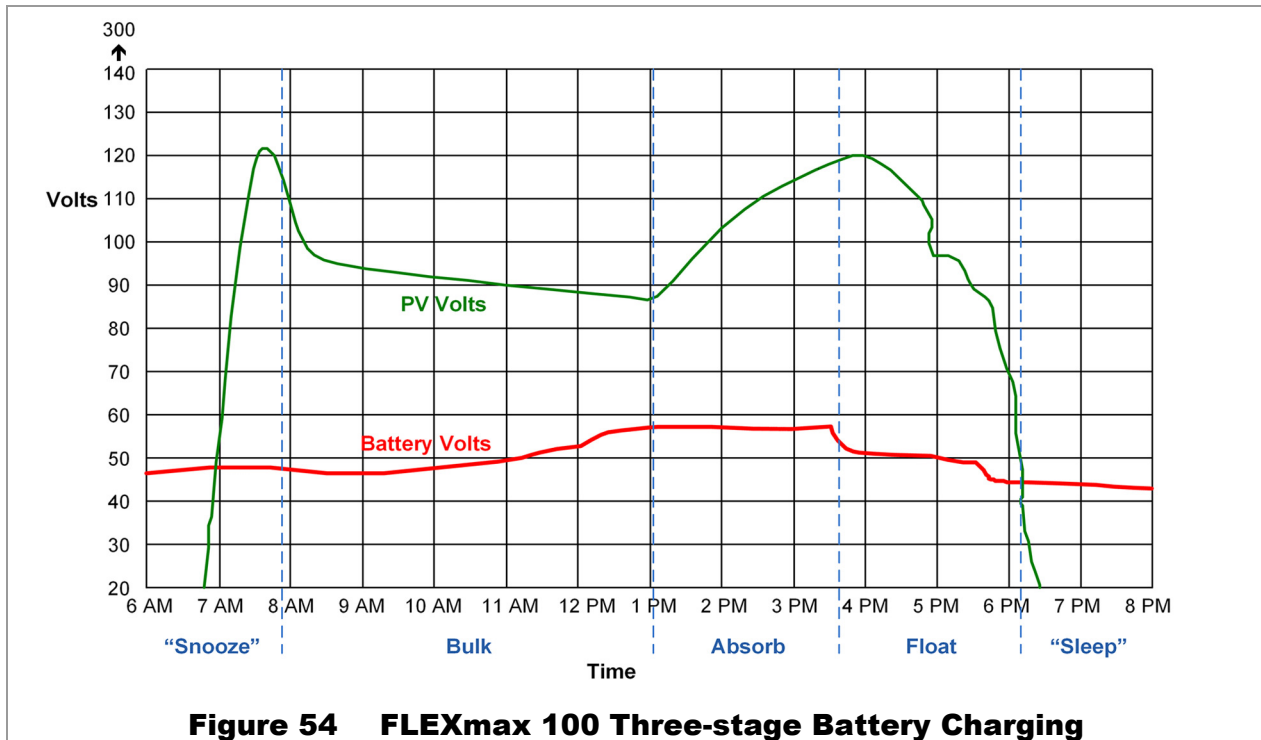


Figure 53 Maximum Power Point Tracking

Three-Stage Battery Charging

The FLEXmax 100 charge controller is a sophisticated, multi-stage battery charger that uses several regulation stages to allow fast recharging of the battery system while ensuring a long battery life. This process can be used with both sealed and non-sealed batteries. The FLEXmax 100 is a “buck” converter which turns higher PV voltages into the lower charging voltages used by batteries (with correspondingly higher currents). The chart in Figure 54 shows the voltage levels achieved by the PV array throughout a typical day, and the battery voltages (by stage) during the same times.

The FLEXmax 100 has preset recharging voltage set points (Absorbing and Float voltages); however, OutBack always recommends using the battery manufacturer’s recommended charging voltages.



A new charge cycle is started any time the battery voltage decreases below the **Rebulk** set point for 90 seconds or more. (See page 42.) This usually occurs each night unless the batteries were maintained by another means. (If so, they may not need to be recharged).

Bulk

This is the first stage in the three-stage charge cycle. It is a constant-current stage which drives the battery voltage up. The DC current is the maximum current the charger can deliver. This stage typically leaves the batteries at 75% to 90% of their capacity, depending on conditions.

In Bulk, the controller will charge the batteries to the **Absorbing** voltage setting (see page 42). This stage is not timed. It will charge as long as necessary, regardless of any timer set points. If little PV energy is available, it may take a long time for Bulk to complete. If the FLEXmax 100 is in a different charging stage and little PV energy is available, it may return to Bulk. (See page 31.) This stage is temperature-compensated. (See page 68.)

Absorption

This is the second stage of charging. It is a constant-voltage stage. Current varies as needed to maintain the **Absorbing** voltage setting, but will typically decrease to a very low number over time. This “tops off the tank”, leaving the batteries at essentially 100% of capacity.

Applications

The duration of the Absorption stage is the user-defined **Absorb Time Limit**. Once in Absorbing, the internal counter will count until it reaches this limit. (See page 32.) The controller will then exit Absorbing and enter the Float stage. The charger will also exit Absorbing if the **Absorb End Amps** setting is reached, regardless of the timer. This resets the timer to zero. (See page 42.) This stage is temperature compensated. (See below.)

Float

This is the third stage of charging. It is a constant-voltage stage. The batteries are maintained at the **Float** set point. This stage is not timed. The FLEXmax 100 will continue to maintain **Float** as long as PV energy is available. Current varies as needed to maintain the voltage, but typically drops to a low number.

If the PV cannot supply enough power to maintain the **Float** set point, the FLEXmax 100 will not immediately initiate a new charge cycle. It will attempt to draw more PV energy and recharge the battery until the Float voltage set point is reached. This stage is temperature compensated. (See below.)

A new charge cycle can be initiated if the voltage falls below the **ReBulk** set point for 90 seconds or more (see page 42).

Equalize

Equalization is a controlled overcharge that is part of regular battery maintenance. Equalization follows the same pattern as standard three-stage charging. However, it brings the batteries to a much higher voltage and maintains this voltage for a period of time. This has the result of removing inert compounds from the battery plates and reducing stratification in the electrolyte.

The set points for equalization are adjustable with the system display. See page 44.



CAUTION: Battery Damage

- ❖ Do not equalize any sealed battery types (VRLA, AGM, Gel, or other) unless approved by the manufacturer. Some batteries may suffer severe damage from equalization.
- ❖ Contact the battery manufacturer for recommendations on equalization voltage, duration, schedule, and/or advisability. Always follow manufacturer recommendations for equalization.

Equalization is normally performed only on flooded lead-acid batteries. The schedule for equalization varies with battery use and type, but it is usually performed every few months. If performed correctly, this process can extend battery life by a considerable amount.

Equalization can be triggered manually. To trigger equalization, press the EQ button located on the front of the charge controller. (See page 8.) Hold this button for 5 to 10 seconds, then release. Once triggered, the Status indicator begins alternating amber and green once per second. If the batteries are below 1.75 Vpc, the Status indicator will alternate amber and red. (See page 30.)

Equalization can also be triggered on an automatic schedule. The settings for this schedule are adjustable with the system display. See page 44.

Battery Temperature Compensation

Battery performance changes when the temperature varies above or below room temperature (77°F or 25°C). Temperature compensation is a process that adjusts charging to correct for these changes.

When a battery is cooler than room temperature, its internal resistance goes up and the battery voltage changes more quickly. This makes it easier for the charger to reach its voltage set points. However, while accomplishing this process, the charger will not deliver all the current that the battery requires. As a result, the battery will tend to be undercharged.

Conversely, when a battery is warmer than room temperature, its internal resistance goes down and the voltage changes more slowly. This makes it harder for the charger to reach its voltage set points. It will continue to deliver energy as time passes until the charging set points are reached. However, this tends to be far more than the battery requires, meaning it will tend to be overcharged.

The FLEXmax 100 controller, when equipped with the Remote Temperature Sensor (RTS), will compensate for temperature. The RTS is attached to a single battery near the center of the bank. When charging, the RTS will increase or decrease the charge voltage by 5 mV per degree Celsius per battery cell. This setting affects the **Absorbing** and **Float** set points. Equalization is not compensated in the FLEXmax 100.

There can be side effects to temperature compensation. During cold weather, a battery often requires a higher charging voltage. Some inverters might not accommodate these higher voltages and can shut down during charging, cutting off power to their loads. In addition, some battery manufacturers specify not to exceed a certain voltage due to the risk of battery damage.

To accommodate these problems, the FLEXmax 100 has adjustable compensation limits. It also has an adjustable rate of compensation (“slope”) to meet the requirements of certain batteries. The default slope value is 5 mV per degree C.

When the system includes an OutBack HUB Communications Manager and a system display, only one RTS is needed for multiple inverters and charge controllers.

See page 43 for more information on these items.

Table 14 Examples of Compensation

Cells (volts)	Slope Value	Temp	25° ±	Calculation	Total Compensation
12 (24 Vdc)	3 mV	36°C	+11	$12 \times 0.003 \times 11$	-0.4 Vdc
18 (36 Vdc)	5 mV	26°C	+1	$18 \times 0.005 \times 1$	-0.1 Vdc
24 (48 Vdc)	6 mV	0°C	-25	$24 \times 0.006 \times 25$	+3.6 Vdc

FLEXnet DC Battery Monitor (FN-DC)

The OutBack FLEXnet DC will work normally if it is networked with the FLEXmax 100 and OutBack inverters. This requires a HUB Communications Manager.

If the FN-DC is networked exclusively with FLEXmax 100 charge controllers and a HUB product, jumper **J4** must be in the left-hand position as shown in item **A** below. This position connects pins **AGND** and **ISO-GND**. The FN-DC will not function until this is done.

Any devices connected to the **Aux+** and **Aux-** terminals should be electrically isolated. (Examples include, but are not limited to, coil relays, optical isolators, or fans.)



CAUTION: Equipment Damage

Using non-isolated devices in this application can damage the controller and other devices. This damage is not covered under warranty.



Figure 55 Position of J4 for the FN-DC

Positive-Ground Applications

The FLEXmax 100 can be used in a positive-ground system. However, due to internal grounding paths between the controller and other devices, positive grounding allows only certain combinations of devices in the configuration. These combinations are dependent upon whether or not the system is networked together or the devices stand alone.

See page 14 for instructions and initial restrictions on positive grounding.



CAUTION: Equipment Damage

A system requiring positive grounding should only use the configurations specified in this section. Connecting the FLEXmax 100 in other positive-ground configurations can damage the controller and other devices. This damage is not covered under warranty.

Positive-Ground Networked Devices

A networked system includes the HUB Communications Manager and a MATE3s system display in the configuration. The following conditions apply for all positive-ground devices communicating within the system. They do not apply to non-communicating devices. (See below.)

- Multiple FLEXmax 100 controllers can be networked on the HUB product.
- One OutBack inverter can be networked with one or more FLEXmax 100 controllers on the HUB product under the following conditions:
 - ~ The FLEXnet DC Battery Monitor (FN-DC) is not present on the network
 - ~ No devices are connected to the CAT5 port on the system displayThis configuration is depicted on page 22.
- Instead of an inverter, one previous-model OutBack controller (FLEXmax or MX Series) can be networked with the FLEXmax 100 under the same conditions as above.
- **NOTE:** Multiple OutBack inverters cannot be networked with this charge controller.
- The FN-DC can be networked with one or more FLEXmax 100 controllers under the following conditions:
 - ~ No OutBack inverters are on the network
 - ~ No previous-model OutBack charge controllers are on the network
 - ~ No devices are connected to the CAT5 port on the system display
- The CAT5 port on the system display can be used if the network is limited to one or more FLEXmax 100 controllers. No other OutBack devices can be present.
- Any devices connected to the **AUX+** and **AUX-** terminals should be electrically isolated. (Examples include, but are not limited to, coil relays, optical isolators, or fans.) This can be ignored if no devices are connected to the HUB/Display port.

Positive-Ground Non-Networked Devices

Non-networked devices provide information individually instead of using a HUB communications manager or a single system display. This definition also applies to devices which work in common with a networked system but do not communicate with it.

The restrictions under “Positive-Ground Networked Devices” do not apply when using the FLEXmax 100 in a positive-ground system with non-networked devices. For example:

- The system display CAT5 port can be used with both the FLEXmax 100 and an inverter if the system display is plugged directly into the FLEXmax 100.
- Multiple inverters (for independent loads, not stacked) can be used if they are not connected to the HUB communications manager.

NOTE: Other, non-OutBack devices may have their own restrictions.

Grid-Interactive Settings

When using an OutBack inverter, FLEXmax 100, HUB Communications Manager, and system display, set the Grid-Tie Mode menu to **Y** in the system display. This mode allows the inverter to manage the charge controller's Float setting. It ensures the controller always keeps the battery above the sell voltage of the inverter. (See page 44.)

When using a FLEXmax 100 charge controller with an inverter without the use of a HUB, GT mode will not work because the charge controller cannot communicate with the inverter. In this situation, when selling electricity back to the grid, keep the inverter's "sell" voltage setting below the charge controller's Float setting. In a 24-volt battery system, the difference should be at least 0.5 Vdc. In a 48-volt system, the difference should be at least 1.0 Vdc.

Definitions

The following is a list of initials, terms, and definitions used with this product.

Table 15 Terms and Definitions

Term	Definition
AC	Alternating Current; refers to voltage produced by the inverter, utility grid, or generator
AGS	Advanced Generator Start
AUX	Charge controller's 12-volt auxiliary output
CE	Conformité Européenne; French for "European Conformity"; a marking on OutBack products indicating that they meet European Union requirements
DC	Direct Current; refers to voltage produced by the batteries or renewable source
Derate	Automatic reduction of the FLEXmax 100 rated output of 100 Adc; usually performed for temperature reasons
DVM	Digital Voltmeter
EMI	Electromagnetic Interference; a detrimental condition that affects electronic circuits
FET	Field Effect Transistor; a reference to a temperature reading by the FLEXmax 100
FN-DC	FLEXnet DC; the OutBack Battery Monitor
GFDI	Ground Fault Detector/Interruptor; shuts down the system if a ground fault event occurs
Grid-interactive, grid-tie	Utility grid power is available for use and the system is capable of returning (selling) electricity back to the utility grid
Ground Fault	An unsafe condition of current flow to ground, resulting from accidental contact between an electrical source and ground
I_{mp}	Maximum-power current; the current harvested by MPPT when operating at the V_{mp}
I_{sc}	Short-circuit current; the fully-loaded current displayed by a PV module or array
LED	Light-Emitting Diode; refers to indicators used by the FLEXmax 100 and the system display
MPP, MPPT	Maximum Power Point, Maximum Power Point Tracking
Negative-Ground	A wiring system that bonds the negative conductor to ground for safety

Table 15 Terms and Definitions

Term	Definition
Network	A set of OutBack devices which communicate on a bus established by the HUB Communications Manager
Positive-Ground	A wiring system that bonds the positive conductor to ground for safety
PWM	Pulse-Width Modulation
PV	Photovoltaic
Rapid Shutdown	A function allowing emergency responders to quickly place the PV system in a de-energized state; required by NEC 690.12
RTS	Remote Temperature Sensor; accessory that measures battery temperature for charging
SD card	Secure Digital card; a non-volatile memory card for data storage
“Sleep” mode	No PV energy; normal at night
Slope	A selectable rate of battery temperature compensation
“Snooze” mode	Low light conditions; not enough PV energy for operation
Soft key	A key with functions that vary with screen
Sweep	Part of the MPPT process; the controller is attempting to locate the V_{mp}
System display	Remote interface (such as the MATE3, MATE3s, or OPTICS RE), used for monitoring, programming and communicating with the inverter
V_{mp}	Maximum-power voltage; the voltage sought by MPPT where maximum power is harvested
V_{oc}	Open-circuit voltage; the unloaded voltage displayed by a PV module or array
V_{pc}	Volts per (battery) cell
“Wakeup” mode	Controller has detected a voltage change and has left "snooze" mode but has not yet begun charging; a new sweep is being performed



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Corporate Headquarters
17825 – 59th Avenue N.E.
Suite B
Arlington, WA 98223 USA
+1.360.435.6030

European Office
Hansastraße 8
D-91126
Schwabach, Germany
+49.9122.79889.0